

**Health Impact Review of HB 1550
Concerning methods to prevent nicotine addiction
(2021 Legislative Session)**

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Full review

The full Health Impact Review report is available at:

<https://sboh.wa.gov/Portals/7/Doc/HealthImpactReviews/HIR-2021-12-HB1550.pdf>

Acknowledgements

We would like to thank the key informants who provided consultation and technical support during this Health Impact Review.

Disclosure

The State Board of Health conducts Health Impact Reviews in collaboration with the Governor’s Interagency Council on Health Disparities.

During the 2019 Legislative Session, the State Board of Health was allocated ongoing funding through Foundational Public Health Services for 0.6 FTE to support Health Impact Review work. The Board is seeking funding for additional capacity (0.8 FTE) to support Health Impact Review work as part of the 2021-2023 Foundational Public Health Services budget request.

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Executive Summary
HB 1550, Concerning methods to prevent nicotine addiction (2021 Legislative Session)

Evidence indicates that HB 1550 would likely increase the price of vapor products for consumers, which would decrease purchasing and use of vapor products (particularly among adolescents and young adults) and improve health outcomes. The impacts on equity are unclear.

BILL INFORMATION

Sponsors: Pollet, Cody, Callan, Taylor, Duerr, Ryu, Valdez and Senn

Summary of Bill:

- Imposes a business and occupation surcharge of 4.4% on manufacturers, processors for hire, and distributors of vapor products and tobacco products.
- Replaces the variable milliliter tax imposed on vapor products distributors with a vapor product excise tax of 33%^A of the selling price.
- Modifies the account distribution for receipts of the vapor products tax revenues.

HEALTH IMPACT REVIEW

Summary of Findings:

This Health Impact Review found the following evidence for the specified provision in HB 1550:

- **Informed assumption** that changing the surcharge and tax on businesses distributing vapor products will increase the price of vapor products for consumers. This assumption is based on provisions of the bill and information from the Department of Revenue.
- **A fair amount of evidence** that increasing the price of vapor products for consumers will decrease purchasing and use of vapor products, particularly among adolescents and young adults.
- **Very strong evidence** that decreasing purchasing and use of vapor products among adolescents and young adults will likely improve health outcomes for these individuals.
- **Unclear evidence** of how changing the surcharge and excise tax imposed on vapor products would impact health inequities as there is limited research looking at the impact of imposing a value-based tax on vapor products by subpopulations or communities and since other factors, such as the price of vapor products on tribal lands, may influence how this bill impacts inequities.

^A [1550 AMH FIN HARA 287](#) changes the vapor products tax rate from 45% (as proposed in the original bill) to 33%. Prior to completing the HIR, Representative Pollet requested the review use a tax rate of 33%. The amendment was proposed, but not yet adopted, at the time this HIR was completed.

Introduction and Methods

A Health Impact Review is an analysis of how a proposed legislative or budgetary change will likely impact health and health disparities in Washington State ([RCW 43.20.285](#)). For the purpose of this review ‘health disparities’ have been defined as differences in disease, death, and other adverse health conditions that exist between populations ([RCW 43.20.270](#)). Differences in health conditions are not intrinsic to a population; rather, inequities are related to social determinants (e.g., access to healthcare, economic stability, racism). This document provides summaries of the evidence analyzed by State Board of Health staff during the Health Impact Review of House Bill 1550 ([HB 1550](#)).

Staff analyzed the content of HB 1550 and created a logic model depicting possible pathways leading from the provisions of the bill to health outcomes. We consulted with experts and contacted key informants about the provisions and potential impacts of the bill. We conducted an objective review of published literature for each pathway using databases including PubMed, Google Scholar, and University of Washington Libraries. More information about key informants and detailed methods are available upon request.

The following pages provide a detailed analysis of the bill, including the logic model, summaries of evidence, and annotated references. The logic model is presented both in text and through a flowchart (Figure 1). The logic model includes information on the strength-of-evidence for each pathway. The strength-of-evidence has been defined using the following criteria:

- **Very strong evidence:** There is a very large body of robust, published evidence and some qualitative primary research with all or almost all evidence supporting the association. There is consensus between all data sources and types, indicating that the premise is well accepted by the scientific community.
- **Strong evidence:** There is a large body of published evidence and some qualitative primary research with the majority of evidence supporting the association, though some sources may have less robust study design or execution. There is consensus between data sources and types.
- **A fair amount of evidence:** There is some published evidence and some qualitative primary research with the majority of evidence supporting the association. The body of evidence may include sources with less robust design and execution and there may be some level of disagreement between data sources and types.
- **Expert opinion:** There is limited or no published evidence; however, rigorous qualitative primary research is available supporting the association, with an attempt to include viewpoints from multiple types of informants. There is consensus among the majority of informants.
- **Informed assumption:** There is limited or no published evidence; however, some qualitative primary research is available. Rigorous qualitative primary research was not possible due to time or other constraints. There is consensus among the majority of informants.

- **No association:** There is some published evidence and some qualitative primary research with the majority of evidence supporting no association or no relationship. The body of evidence may include sources with less robust design and execution and there may be some level of disagreement between data sources and types.
- **Not well researched:** There is limited or no published evidence and limited or no qualitative primary research and the body of evidence has inconsistent or mixed findings, with some supporting the association, some disagreeing, and some finding no connection. There is a lack of consensus between data sources and types.
- **Unclear:** There is a lack of consensus between data sources and types, and the directionality of the association is ambiguous due to potential unintended consequences or other variables.

This review was subject to time constraints, which influenced the scope of work for this review. The annotated references are only a representation of the evidence and provide examples of current research. In some cases, only a few review articles or meta-analyses are referenced. One article may cite or provide analysis of dozens of other articles. Therefore, the number of references included in the bibliography does not necessarily reflect the strength-of-evidence. In addition, some articles provide evidence for more than one research question, so are referenced multiple times.

Analysis of HB 1550 and the Scientific Evidence

Summary of relevant background information

- Excise taxes are paid when purchases are made on a specific good and are often included in the price of the product.¹ Excise taxes can also be levied on activities.¹
- In June 2009, the Family Smoking Prevention and Tobacco Control Act (2009 Tobacco Control Act) was signed into law in part to reduce smoking rates among adolescents.² It gave the U.S. Food and Drug Administration (FDA) authority to regulate the manufacture, distribution, and marketing of tobacco products.² The Tobacco Control Act banned flavors, except menthol and tobacco, in cigarettes² specifically as one strategy to reduce the use of cigarettes among young people.
- In May 2016, the FDA finalized a rule to extend its authority over all tobacco products, known as the ‘Deeming Rule.’³ Newly regulated products, including electronic cigarettes, were required to comply with all Federal Food, Drug, and Cosmetic Act and FDA regulations specific to tobacco products.³
- In 2018, the FDA took action to reduce youth access to e-cigarettes. The FDA:
 - Issued 1,300 warning letters and fines to “retailers who illegally sold JUUL and other e-cigarette products to minors,” marking the “largest coordinated enforcement effort in the FDA’s history.”⁴ As of September 11, 2019, FDA had issued more than 8,600 warning letters and more than 1,000 fines to retailers (both online and brick-and-mortar stores) for sales of electronic nicotine delivery systems (ENDS) and their components to minors.⁵
 - Issued letters to the top five-selling e-cigarette brands (which comprise 97% of the U.S. e-cigarette market) requiring each company to submit plans detailing how they will limit marketing and youth access to their product.⁴
 - Launched “The Real Cost” youth e-cigarette prevention campaign.⁶
 - Issued a directive that all “flavored ENDS products (other than tobacco, mint, and menthol flavors or non-flavored products) must be sold in age-restricted, in-person locations and, if sold online, under heightened practices for age verification.”⁶
- In December 2018, the Office of the Surgeon General issued an advisory about e-cigarette use among youth.⁷ The statement noted that, “any e-cigarette use among young people is unsafe, even if they do not progress to future cigarette smoking.”⁷
- On March 27, 2019, the Washington State Legislature passed Engrossed House Bill (EHB) 1074 (Chapter 15, Laws of 2019), Protecting youth from tobacco products and vapor products.⁸ The law increased the legal age of sale of tobacco and vapor products from 18 to 21 years of age and permitted the Governor to seek government-to-government consultations with tribes about raising the minimum legal age of sale in cigarette tax compacts. The law was effective January 1, 2020.
 - [RCW 43.06.455](#) allows the Governor to enter into cigarette tax compacts with tribes and applies to the sale of all tobacco and vape products sold on tribal lands. Statute specifies that, “a cigarette tax contract with a tribe shall provide for a

tribal cigarette tax in lieu of all state cigarette taxes and state and local sales and use taxes on sales of cigarettes in Indian country by Indian retailers.”

- In July 2019, FDA launched its first youth e-cigarette prevention TV ads educating youth about the dangers of e-cigarette use.⁹
- In July 2019, the Centers for Disease Control and Prevention (CDC), FDA, state and local health departments, and other clinical and public health partners began investigating a national outbreak of e-cigarette, or vaping, product use-associated lung injury (EVALI).¹⁰ The investigation is on-going, and the most recent data reported is from February 18, 2020. At that time, CDC reported a total of 2,807 hospitalized EVALI cases or deaths from all 50 states, the District of Columbia, Puerto Rico, and U.S. Virgin Islands.¹⁰ Cases peaked in September 2019 and have since declined due to increased public awareness, removal of Vitamin E acetate from some products, and law enforcement action to restrict illicit products.¹⁰ CDC stated that, “laboratory data show that vitamin E acetate, an additive in some THC-containing e-cigarette, or vaping, products, is strongly linked to the EVALI outbreak.”¹⁰
 - On September 11, 2019, Public Health – Seattle & King County (PHSKC) announced the first confirmed Washington State case of EVALI in a King County teenager.¹¹
 - On September 27, 2019, Governor Inslee issued Executive Order 19-03, Addressing the Vaping Use Public Health Crisis (Executive Order). Among other directives, the Executive Order directed DOH to “request the State Board of Health [SBOH] use its emergency rulemaking authority to impose a ban on all flavored vapor products, including THC vapor products, at the Board’s next meeting on October 9 [2019].”¹² The Executive Order became effective immediately.
 - On October 9, 2019, SBOH adopted the emergency rulemaking order to create chapter 246-80 Washington Administrative Code (WAC).¹³ Chapter 246-80 WAC “bans the sale of flavored vapor products, including flavored THC vapor products, requires non-marijuana vapor product retailers to display a warning of the risk of lung disease associated with the use of vapor products, and requires reporting of cases of lung injury associated with use of vapor products from health care providers and health care facilities.”¹⁴ The emergency rule became effective October 10, 2019 and expired on February 7, 2020 (i.e., after 120 days).¹⁵
 - On November 18, 2019, SBOH adopted a second emergency rule prohibiting the sale of vapor products containing vitamin E acetate (WAC 246-80-021).¹⁴ The emergency rule became effective November 20, 2019 and was renewed March 19, 2020. It is set to expire on July 17, 2021.¹⁶
 - Washington State Department of Health (DOH) reported that, “since April 2019, there have been 27 cases of [EVALI] in Washington, including two deaths.”¹⁷

- In October 2019, the implementation of [RCW 82.25.010](#) imposed a vapor products tax of \$0.09 per milliliter of liquid or solution for accessible containers of liquid solution that are larger than 5 milliliters or \$0.27 per milliliter of liquid solution for all other vapor products.
 - “Vapor products” are defined as “any noncombustible product containing a solution or other consumable substance, regardless of whether it contains nicotine, which employs a mechanical heating element, battery, or electronic circuit that can be used to produce vapor from the solution or other substance. For purposes of taxation, vapor products do not include tobacco cessation products, component ingredients in vapor products, or marijuana or tobacco products.”
 - The distributor is responsible for the payment of the tax, but the tax may be imposed on the consumer if it was not previously collected.
- On December 20, 2019, the Federal Food, Drug, and Cosmetic Act was modified to raise the federal minimum age for sale of tobacco products from 18 years to 21 years.¹⁸ The change applied to all tobacco products, including cigarettes, cigars, and e-cigarettes, and was effective immediately.¹⁸
- In January 2020, the FDA issued a “policy prioritizing enforcement against certain unauthorized flavored e-cigarette products that appeal to kids, including fruit and mint flavors.”¹⁹
- The World Health Organization (WHO) has concluded that, “available evidence suggests that smoking is associated with increased severity of disease and death in hospitalized COVID-19 patients.”²⁰

Summary of HB 1550

- Imposes a business and occupation surcharge of 4.4% on manufacturers, processors for hire, and distributors of vapor products and tobacco products.
- Replaces the variable milliliter tax imposed on vapor products distributors with a vapor product excise tax of 33%^B of the selling price.
- Modifies the account distribution for receipts of the vapor products tax revenues.
 - Tax revenues are distributed as follows: the first \$25 million into the Foundational Public Health Services (FPHS) Account ([RCW 43.70.515](#)); 50% of the next \$10 million into the Andy Hill Cancer Research Endowment Fund Match Transfer Account (Andy Hill CARE Fund); and all remaining funds into the FPHS Account.

Health impact of HB 1550

Evidence indicates that HB 1550 would likely increase the price of vapor products for consumers, which would decrease purchasing and use of vapor products (particularly among adolescents and young adults) and improve health outcomes. The impacts on equity are unclear.

^B [1550 AMH FIN HARA 287](#) changes the vapor products tax rate from 45% (as proposed in the original bill) to 33%. Representative Pollet requested the review use a tax rate of 33%. The amendment was proposed, but not yet adopted, at the time this HIR was completed.

Pathway to health impacts

The potential pathway leading from the provisions of HB 1550 to health inequities are depicted in Figure 1. We have made the informed assumption that changing the surcharge and tax on businesses distributing vapor products will increase the price of vapor products for consumers. This assumption is based on provisions in the bill and information from the Department of Revenue. There is a fair amount of evidence that increasing the price of vapor products for consumers will decrease purchasing and use of vapor products, particularly among adolescents and young adults.²¹⁻²⁴ There is very strong evidence that decreasing use of vapor products among adolescents and young adults will likely improve health outcomes for these individuals.²⁵⁻⁴¹ Finally, it is unclear how the bill will impact health inequities.⁴²⁻⁴⁷

Scope

For this review, we were only able to research the most direct connections between the provisions of the bill and decreased health inequities and did not explore the evidence for all possible pathways. Therefore, this Health Impact Review focused on the impact that changing the surcharge and excise tax imposed on vapor products would have on health outcomes and health equity for adolescents and young adults. Additional potential pathways are discussed in “Other Considerations” beginning on page 18. We did not evaluate potential impacts related to:

- The economic impacts of the business and occupation surcharge or of changing the excise tax imposed on vapor products on industry or businesses.
- Tax enforcement for vapor products. The Washington State Liquor and Cannabis Bureau (LCB) did not receive funding in EHB 1074 (Chapter 15, Laws of 2019) to conduct tax enforcement for vapor products and do not currently conduct enforcement operations (e.g., audits, investigations into complaints) (personal communication, LCB, March 2021). Similarly, HB 1550 does not include provisions related to enforcement. Tax enforcement activities have the potential to recover unpaid vapor taxes or deter tax evasion. For example, when the Legislature allocated funding to LCB to conduct tobacco tax enforcement the agency recovered additional funds beyond the cost of the enforcement (personal communication, LCB, March 2021). Specifically, from November 1, 2015 to January 31, 2021, LCB’s tobacco tax enforcement activities recovered more than \$55.1 million in additional tax revenue (unpublished data, LCB, March 2021).
- Economic stability for individuals who continue to purchase vapor products.
- Initiation of combustible tobacco products. Previous Health Impact Reviews related to use of flavored vapor products by adolescents and young adults have found strong evidence that decreasing initiation and use of vapor products among adolescents and young adults will likely result in decreased initiation and use of other tobacco products by these populations.^{26,37-39,48,49} Evidence shows the use of e-cigarettes among youth is associated with future use of combustible cigarettes,^{26,37-40,48} potentially increasing risk of long-term negative health outcomes and resulting in an overall net negative impact on public health.^{6,26}

Magnitude of impact

The Washington State Department of Revenue (DOR) estimated that a business and occupation surcharge on vapor products would impact 2,000 manufacturers, processors for hire, and distributors of vapor products in Washington State.⁵⁰ HB 1550 stipulates that a state excise tax

on vapor products must be reflected in the shelf price of vapor products sold in stores. Therefore, the tax would likely impact any individual purchasing vapor products in the state. However, “tribal members/citizens do not pay state taxes for their transactions that occur in their Indian Country”,⁵¹ and the proposed excise tax on vapor products “does not apply to sales of vapor products by an Indian retailer under a vapor product tax contract or agreement.”⁵²

DOR estimated that the additional net revenue from the business and occupation surcharge and the state excise tax would be \$12.4 million for the 2022-2023 biennium; \$14.6 million for the 2024-2025 biennium; and \$14.3 million for the 2026-2027 biennium (unpublished data, DOR, March 2021).

Nationally, tobacco product use among middle and high school students decreased from 2011 to 2020.^{53,54} E-cigarettes remain the most commonly used tobacco product among youth.⁵⁴ While e-cigarette use statistically significantly increased from 1.5% of high school students in 2011 to 20.8% of high school students in 2018,⁵⁵ data from the 2019 and 2020 National Youth Tobacco Surveys showed that e-cigarette use declined from 2019 to 2020.⁵⁴ E-cigarette use decreased from 27.5% to 19.6% of high school students and from 10.5% to 4.7% of middle school students.⁵⁴ The Centers for Disease Control and Prevention (CDC) attributed this decline to a number of factors,⁵⁴ including: the 2019 raise in federal minimum age of sale for all tobacco products from 18 to 21 years of age;¹⁸ the Food and Drug Administration’s (FDA) 2020 prioritized enforcement of flavored e-cigarette products that appealed to youth;⁵⁶ FDA’s public education campaign to reduce youth e-cigarette and tobacco use; the outbreak of e-cigarette, or vaping, product use-associated lung injury (EVALI); and state action (including action in Washington State) to restrict access to flavored products.

E-cigarette use in Washington State has likely followed national trends. However, the most current state-level data is from the 2018 Washington State Healthy Youth Survey (HYS). HYS data indicated the prevalence of current (i.e., past 30-day) vapor product use among 6th graders (3%), 8th graders (10%), 10th graders (21%), and 12th graders (30%) had significantly increased since 2016.⁴⁴ HYS results also showed greater statewide prevalence of past 30-day use of both e-cigarettes and cigarettes as grade level increases (6th grade: <1%, 12th grade: 6%).⁴⁴

Logic Model

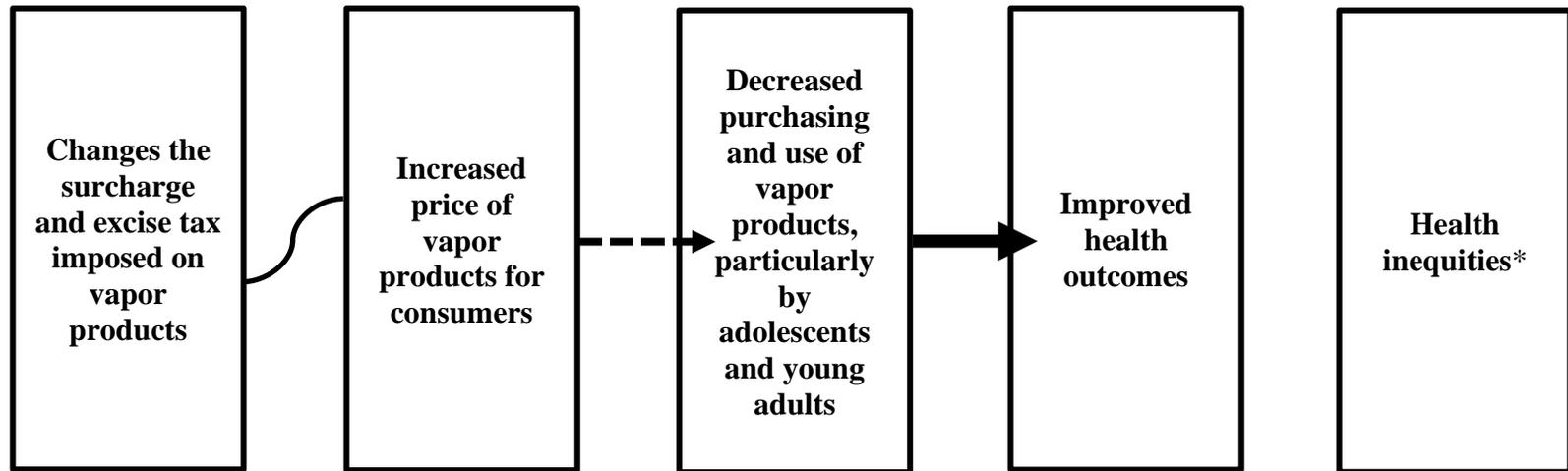
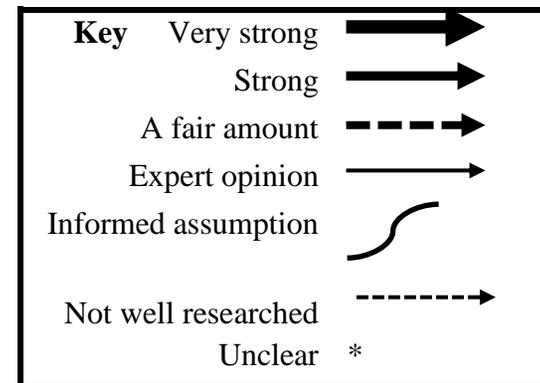


Figure 1:
Concerning methods to prevent nicotine addiction
HB 1550



Summaries of Findings

Will changing the surcharge and tax on businesses distributing vapor products increase the price of vapor products for consumers?

This review makes the informed assumption that changing the surcharge and tax on businesses distributing vapor products will increase the price of vapor products for consumers. This assumption is based on provisions in the bill and information from the Department of Revenue (DOR).

HB 1550 stipulates that the state excise tax on vapor products must be reflected in the shelf price of vapor products in retail stores. DOR stated that provisions of HB 1550 represent both a change to tax structure, as well as an increase in taxes on vapor products compared to current law (personal communication, DOR, March 2021). Under the current excise tax structure, the tax on vapor products is calculated based on the quantity of solution (regardless of whether it contains nicotine or not). As a result, the amount of tax a consumer pays varies depending on product type and size (products greater than five mL are taxed at \$0.09/mL; all other products are taxed at \$0.27/mL) ([RCW 82.25.010](#)).

HB 1550 would change the tax structure from a volume tax to a value tax, such that all products were taxed at the same rate (i.e., 33% of retail price).^C Overall, DOR predicts that the value tax structure proposed by HB 1550 would potentially double the retail price for some vapor products as, “for many products, there will be material increase in retail price for consumers” (personal communication, DOR, March 2021).

However, because the current tax imposed on vapor products is dependent on product type and size, HB 1550 would result in the tax paid by the consumer to increase (or in some cases decrease) by varying amounts (personal communication, DOR, March 2021). For example, according to DOR, for smaller-unit vapor products, the average wholesale price of 1 mL of e-juice is \$3.07.⁵⁰ Under the current volume tax, a customer would pay \$0.27 in tax (\$0.27/mL). However, under a tax at 33% of sales price, a customer would pay \$1.01 in tax, which equates to 374% of the current tax. Therefore, HB 1550 would likely increase the price of smaller-unit vapor products.

Higher volume products have lower wholesale prices. For larger unit vapor products, the average wholesale price per mL of e-juice is \$0.23.⁵⁰ Therefore, a 10 mL vape liquid refill container would cost about \$2.30. Under the current volume tax, a customer would pay \$0.90 in tax (\$0.09/mL). Under a tax of 33% of sales price, a customer would pay \$0.76 in tax, which equates to a 16% reduction compared to the current tax. Therefore, HB 1550 may decrease the price of larger-unit vapor products.

Lessons learned from the taxation of combustible cigarettes can also inform how various types of taxes can influence prices over time. The *Reducing Tobacco Use Report of the Surgeon General* (2000) states “one of the consequences of an excise tax system with relatively infrequent

^C [1550 AMH FIN HARA 287](#) changes the vapor products tax rate from 45% (as proposed in the original bill) to 33%. Representative Pollet requested the review use a tax rate of 33%. The amendment was proposed, but not yet adopted, at the time this HIR was completed.

increases is that, at least during the period between excise tax increases, the real price of cigarettes will fall over time as the prices of other goods and services increase more rapidly.”⁵⁷ Therefore, under the current volume-based excise tax structure lawmakers would need to increase the tax on vapor products regularly to keep pace with inflation to maintain price increases over time. Meanwhile, the proposed tax (33% of price) is an ad valorem tax, meaning it is a fixed percentage of the price, which will increase or decrease as prices continue to change to reflect inflation.⁵⁷

Additionally, HB 1550 would impose a 4.4% business and occupation surcharge on manufacturers, processors for hire, and distributors of vapor products and tobacco products. DOR noted that this surcharge would likely also be passed on to consumers, potentially further raising the retail price of vapor products (personal communication, DOR, March 2021).

Overall, provisions in HB 1550 as well as information from DOR suggest that HB 1550 would result in higher retail prices for consumers purchasing smaller-unit vapor products (popular among adolescents and young adults).

Will increasing the price of vapor products for consumers decrease purchasing and use of vapor products?

There is a fair amount of evidence that increasing the price of vapor products for consumers will decrease purchasing and use of vapor products, particularly among adolescents and young adults.

The 2018 Washington Healthy Youth Survey (HYS) found that, accessing products through non-social sources (e.g., buying from a store, the internet, or a vending machine) was most common among 12th graders (26%) compared to 10th (14%) and 8th graders (16%).⁴⁴ A separate survey of over 1,700 youth aged 15 to 17 years who reported vaping in the past 30 days found that 78.2% owned their own vaping device, with 32.2% purchasing their device online and 22.3% purchasing it in a vapor shop or lounge.⁵⁸ A survey with 9th and 12th grade students in California found that 9.3% reported buying tobacco products (including hookah, e-cigarettes, and cigarettes) from retailers directly.⁵⁹ Social availability was also a large access point, with 72.8% of youth reporting using someone else’s vaping device in the past 30 days, and 80.5% who borrowed stating that they borrowed from a friend.⁵⁸ In Washington State, results of the HYS found roughly 65% of students currently using tobacco and electronic vapor products reported accessing them through social sources (e.g., giving money to someone, “bumming”, from a person aged 18 years or older, and taking from a store or family).⁴⁴ A survey with 9th and 12th grade students in California found that 55% reported getting tobacco products (including hookah, e-cigarettes, and cigarettes) from peers.⁵⁹ One researcher suggested that, “social sources might be even more important for vaping than for smoking cigarettes; cigarette smokers likely get cigarettes from other people only when they do not possess their own, but vapers use others’ devices even when they have their own.”⁵⁸

There is a developing body of evidence examining the own- and cross-price elasticity of demand for e-cigarettes.²¹⁻²⁴ For example, an analysis of purchasing data from 2009 to 2012 estimated a 10% increase in price of disposable e-cigarettes and rechargeable e-cigarettes would decrease sales by 12% and 19%, respectively.²¹ Evidence also indicated that disposable e-cigarettes may be an emerging substitute for rechargeable e-cigarettes, as a 10% increase in the price of

rechargeable products increased sales of disposable products by 5%.²¹ More recently, researchers used 2012-2017 retail data to estimate the effect of prices on both e-cigarette and combustible cigarette sales in California.²³ Evidence indicated that when price increased by 1%, per capita sales would decrease by 0.37% for disposable e-cigarettes, 0.20% for reusable e-cigarettes, and 0.21% for combustible cigarettes.²³ The demand model found no statistically significant associations between cigarette sales and changes in the prices of disposable or reusable e-cigarettes, indicating that combustible cigarettes were not substitutes for e-cigarettes.²³

Two studies have specifically examined the association between e-cigarette (disposable and refill) retail prices and use of these products by adolescents and young adults. For example, researchers used 2014 and 2015 Monitoring the Futures Survey data and retail scanner data to model the association between price and use of e-cigarette products by 8th, 10th, and 12th graders.²² They estimated a 10% increase in prices of disposable e-cigarettes was associated with a significant reduction in the number of days vaping among e-cigarette users and in the number of days vaping by the full sample (9.7% and 17.9%, respectively).²² The model found that the price of refill e-cigarettes were not statistically significant predictors of vaping.²² Another study used an experimental study design to assess price elasticity of demand for a JUUL starter kit (i.e., a device and four flavor pods) among 300 nicotine users and nonusers aged 18 and 19 years.²⁴ Overall, they found “a 10% increase in price leads to as much as a 24% reduction in e-cigarette demand among teens currently using nicotine, and as much as a 45% reduction among teens who are currently not using nicotine.”²⁴ Compared to results of a similar experimental study with adults (mean age of 42 years), the teen sample had a greater price elasticity of demand.²⁴ Therefore, evidence suggests that increased taxes on vapor products may “be highly effective at preventing teens from becoming e-cigarette users in the first place.”²⁴ Similarly, a 2016 Report of the Surgeon General stated that youth and young adults “may be more price-sensitive in the purchase of e-cigarette products, and thus they may be more likely to stop using e-cigarettes as their price increases.”²⁸

Lastly, as prices of e-cigarette products have declined, sales have sharply increased.²⁸ Similarly, it is well documented that increases in the real price (i.e., price as compared to prices of other goods and services) of combustible cigarettes is associated with decreased consumer demand for cigarettes.^{28,57} Evidence has shown that following significant increases in combustible cigarette prices (e.g., passage of the 2009 federal tobacco tax) demand for cessation services generally increases.⁶⁰ Evidence has also demonstrated that youth and young adults tend to be highly sensitive to changes in price of conventional cigarettes.^{28,57} Moreover, prices of e-cigarette products are inversely related to sales volume: as prices have declined, sales have sharply increased.

Under the volume tax law, a customer purchasing a small unit vapor product with an average price of \$3.07 pays \$0.27/mL in tax or about 8.8% in tax.⁵⁰ The proposed 33% ad valorem tax would increase the price of an average priced small unit vapor product by more than 20%. Therefore, since evidence suggests that a 10% increase in price results in statistically significant reductions in purchasing, there is a fair amount of evidence that increasing the price of vapor products will decrease purchasing and using these products, particularly among youth and young adults.

Will decreased purchasing and use of vapor products improve health outcomes?

Use of e-cigarettes has been shown to have negative impacts on health for adolescents and young adults,^{4,6,7,26,28} and there is very strong evidence that decreasing use of vapor products among adolescents and young adults will likely improve health outcomes for these individuals.²⁵⁻⁴¹

Generally, research has shown that e-cigarette use has numerous negative health impacts, including respiratory, cardiac, and digestive system effects; unintentional and intentional poisonings; and injuries due to explosion.⁶¹ In a 2018 report about the public health consequences of e-cigarettes, the National Academy of Sciences stated that, although e-cigarette use poses less risk to individuals than combustible cigarettes, there is conclusive evidence that use of e-cigarettes has multiple adverse impacts on health.²⁶ They found evidence that e-cigarettes can explode and cause burns and injuries; intentional or accidental exposure to e-liquids can result in seizures, anoxic brain injury, vomiting, lactic acidosis, and other effects; and intentionally or unintentionally drinking or injecting e-liquids can be fatal.²⁶ From 2011 to 2017 the Washington Poison Center received 2,966 total cases related to nicotine exposure among children 0 to 12 years of age.²⁹ The majority of cases were in children under 5, and 22% (653) of cases were related to e-cigarettes.²⁹ In 2018, the Washington Poison Center received 136 cases specific to e-cigarettes, including 79 cases among children 0 to 12 years of age.⁶² Children were primarily exposed through ingestion, and experienced symptoms like vomiting, coughing/choking, drowsiness/lethargy, and pallor.²⁹

The National Academy of Sciences also found substantial evidence that e-cigarette use results in symptoms of dependence on e-cigarettes, formation of reactive oxygen species/oxidative stress, increased heart rate shortly after nicotine intake, and exposure to chemicals capable of causing DNA damage and mutagenesis, suggesting the possibility that long-term exposure could increase risk of cancer and adverse reproductive health outcomes.^{26,61} Overall, the report concluded that e-cigarettes contain and emit numerous potentially toxic substances (e.g., metals, mercury, formaldehyde, and other cancer-causing nitrosamines)^{26,63,64} and that nicotine intake among adult e-cigarette users is comparable to intake from combustible tobacco cigarettes.^{26,65} In addition, a study of JUUL products found levels of menthol at concentrations known to increase nicotine intake.⁶⁵ Lastly, a study of adolescents aged 13-18 years old who use e-cigarettes found that, compared to non-users, users had three times greater levels of five volatile organic compounds in their urine and saliva, most of which are known carcinogens.³⁰

A large body of research also found that solvents and flavor chemicals in e-cigarettes cause harm at the cellular level and are cytotoxic.^{50,57,61} Propylene glycol and glycerin are the most common solvents used in vapor products. While both are ‘generally recognized as safe’ for ingestion, propylene glycol and glycerin have been found to be cytotoxic when aerosolized through vaping.^{61,64} One study found that e-liquid refills containing glycerin were the most cytotoxic, and 91% of glycerin-based refill fluids were cytotoxic when aerosolized.⁶¹

There is also research showing that flavor chemicals are cytotoxic in both e-liquid and aerosol form. While many flavor chemicals used in vaping products have been approved for ingestion, they have not been tested for inhalation safety or toxicity.^{61,66-68} Flavor chemicals are not typically listed on e-cigarette packaging,⁶⁸ and most e-liquids contain multiple flavor chemicals. Many have been shown to contain harmful aerosol components and aldehydes, which impair

lung function.^{66,68} One study found that nicotine and flavoring chemicals were equally responsible for compromising lung function.⁶⁶ A study evaluating 36 e-cigarette refill fluids representing a range of brands and flavors found that 54% were cytotoxic in both the fluid and aerosol form, and 23% were cytotoxic in the aerosol but not the fluid form.⁶¹ Another study looking specifically at flavor chemical concentrations in the eight pre-filled JUUL e-cigarette pods available on the market found that all e-liquids and corresponding aerosols were cytotoxic to human lung epithelial cells.⁶⁹ One study demonstrated that a single exposure to cinnamaldehyde flavoring in e-cigarettes impairs lung function, potentially resulting in the development or exacerbation of respiratory disease.^{32,70} Other studies have also shown that cherry-flavored products (benzaldehyde)⁶⁷ and chocolate-flavored products (2,5-dimethylpyrazine)⁷¹ are potentially harmful.⁶¹ Flavor chemical concentrations have also been found in some e-cigarette products at levels that exceed daily occupational exposure limits from inhalation.⁶⁸

Additional emerging research also supports the Institute of Medicine's finding that smoking e-cigarettes is associated with adverse effects such as airway and lung obstruction.²⁸ One study found that e-cigarette use is independently and significantly associated with increased odds of heart attack.³¹ Data from 96,467 respondents to the 2014, 2016, and 2017 National Health Interview Survey found that adults that used e-cigarettes were 34% more likely to have a heart attack and 25% more likely to have coronary artery disease compared to adults that did not use e-cigarettes.⁷² Users were at increased risk of heart attack and coronary artery disease regardless of whether they vaped occasionally or daily.⁷² Other studies have found that e-cigarette devices emit particulate matter and that passive or secondhand exposure to vaping products could impact health.^{41,73} For example, a study among youth in Florida found that secondhand exposure to aerosol from electronic nicotine delivery systems was associated with higher odds of asthma attacks among youth with asthma.⁷³

More recently, the World Health Organization (WHO) concluded that, "available evidence suggests that smoking is associated with increased severity of disease and death in hospitalized COVID-19 patients."²⁰ In a review of 34 peer-reviewed journal articles, WHO identified studies that found a statistically significant association between smoking status and COVID-19 disease severity, admission to an Intensive Care Unit, ventilator use, and death.²⁰

Lastly, evidence shows that most adolescents and young adults do not use e-cigarettes to quit smoking.^{48,74} For example, data from the National Youth Tobacco Survey (2016) showed only 7.8% of respondents who used e-cigarettes cited cessation as a reason for e-cigarette use.⁴⁸

Overall, there is very strong evidence that decreasing use of vapor products among adolescents and young adults will likely improve health outcomes for these individuals.

Will improved health outcomes decrease health inequities?

There is unclear evidence of how changing the excise tax imposed on vapor products would impact health inequities. Inequities are not inherent to an individual's identity. Rather, inequities are influenced by social determinants that systematically marginalize groups due to their identity. For example, adverse health outcomes are not inherent to an individual's race/ethnicity. Rather, they are influenced by social determinants of health like racism, which contributes to other

inequities, like inequities in socioeconomic status, which are associated with adverse opportunities and outcomes. Inequities can be exacerbated or alleviated by intersecting identities, and people of color are more likely to experience low incomes. There has been limited research looking at the impact of imposing a value-based tax on vapor products by subpopulations (e.g. communities with low-incomes, communities of color). Other factors may also influence how this bill impacts inequities such as the price of vapor products on tribal lands.

However, inequities in e-cigarette use are documented⁴²⁻⁴⁷ and presented below.

Inequities by race/ethnicity

Data from the 2018 HYS show e-cigarette use was significantly higher than cigarette use for all grade levels and all races/ethnicities.^{42,75} Survey results indicate that current use of e-cigarettes/vapor products among 10th and 12th graders is higher among American Indian and Alaska Native (AI/AN), multi-racial, and white students than their peers.⁴² Among 8th graders, current use of e-cigarettes/vapor products was higher among Hispanic/Latino, AI/AN, multi-racial, and Black/African American students than other racial/ethnic groups.⁴²

Current law ([RCW 43.06.455](#)) allows the Governor to enter into cigarette tax compacts with tribes, and applies to the sale of all tobacco and vape products sold on tribal lands. The proposed excise tax on vapor products “does not apply to sales of vapor products by an Indian retailer under a vapor product tax contract or agreement.”⁵² However, tribes may choose to adopt a tax at a similar rate, which could increase the shelf price of products sold in tribal stores. Therefore, it is unclear whether changes to the state excise tax on vape products may impact the shelf price of products sold on tribal lands and it is possible that vape product use rates among AI/ANs and other Washingtonians living on or accessing goods on tribal land will not be as positively impacted by HB 1550. If this leads to a greater decline in vaping use among other subpopulations, this could exacerbate the vaping inequities that currently exist for AI/AN communities in Washington.

For example, following a menthol cigarette ban in Ontario, Canada, “22% of the daily menthol cigarette users reported purchasing menthol cigarettes after the ban” compared to 5% of the occasional menthol users and 0.3% of the non-menthol smokers.⁷⁶ The primary source for purchasing menthol cigarettes was on First Nation Reserves.⁷⁶ This purchasing pattern did not increase over time among prior daily menthol smokers (21% at both short-term and long-term follow-up).⁷⁶ Results were consistent with previous research findings that “25% of menthol smokers claim that they would find some way to purchase menthol cigarettes despite a ban.”⁷⁶

Overall, it is unclear how the bill would impact communities in Washington, especially for AI/AN youth and other youth living on or accessing vape products on tribal land.

Inequities by sexual orientation and gender identity

Nationally, students identifying as gay, lesbian, and bisexual were more likely to use e-cigarettes than students who identify as heterosexual (17.5% versus 13.2%, respectively).⁴³ Results of the 2018 HYS show that current use of e-cigarette/vapor products varied by sexual orientation.⁴² Among 10th graders, 32.1% of gay, lesbian, or bisexual students; 23.6% of those who indicate

they are “questioning, something else fits;” and 20.8% of students identifying as heterosexual reported current e-cigarette use.⁴²

Additionally, results of the 2018 HYS show that current e-cigarette use among 10th graders varied by gender identity. Transgender students reported the greatest current use (44.7%) followed by students who felt something else fits better (30.0%), students questioning/not sure of their gender identity (24.4%), cis-gender female students (22.4%), and cis-gender male students (20.8%).⁴⁴

Overall, while LGBTQIA adolescents and young adults experience inequities in e-cigarette use, because there is a lack of research on how a value based tax would impact use of these products specifically among LGBTQIA adolescents and young adults, it is unclear how the bill would impact this population.

Inequities by socioeconomic status

The associations between smoking combustible cigarettes and socioeconomic status (SES) are well documented in the literature.²⁸ Evidence has also demonstrated that “those with low SES, tend to exhibit higher sensitivity to changes in the price of conventional cigarettes.”²⁸

Generally, lower SES is associated with greater exposure to tobacco cigarette advertising and cigarette use.^{45,77} However, evidence from Connecticut found “higher SES was associated with greater [e-cigarette specific] advertising exposure. Furthermore, exposure to more advertising was significantly associated with using e-cigarettes more frequently.”⁴⁵ This aligns with information shared by a key informant in California who indicated the higher initial costs (compared to other flavored tobacco products) of vapor starter kits (typically \$30-\$50) make these products more accessible to higher SES adolescents and young adults (San Francisco Department of Public Health, personal communication, September 2019). Results of the 2017-2018 California Student Tobacco Survey show the prevalence of current e-cigarette use among students (8th, 10th, and 12th grades) in San Francisco and San Mateo Counties (20.8%) is nearly double that of current use among their peers statewide (10.9%).⁴⁶ In 2017, the median household income in both San Mateo County (\$116,653) and San Francisco County (\$110,816) were well above the statewide median (\$71,805).⁷⁸ Additional research is necessary to examine the association between SES and e-cigarette use over time.

Overall, since there is limited research looking at the impact of imposing a value-based tax on vapor products by subpopulations or communities and since other factors may influence how this bill impacts inequities such as the price of vapor products on tribal lands, the impact on health inequities is unclear.

Other considerations

This Health Impact Review focused on the most direct pathway between provisions in the bill and health outcomes and health equity. We also examined the potential impact of the reinvestment of tax revenue and use of vape products for cessation.

Impacts of tax revenue

HB 1550 stipulates the first \$25 million collected from the vapor products tax is to be deposited into the Foundational Public Health Services (FPHS) account ([RCW 82.25.015](#)). [RCW 43.70.512](#) (Public health system—Foundational public health services—Intent) states that the governmental public health system (comprised of the State Department of Health, State Board of Health, local health jurisdictions, sovereign tribal nations, and Indian health programs) is responsible for delivering a set of core public health services “in ways that maximize the efficiency and effectiveness of the overall system, make best use of the public health workforce and evolving technology, and address health equity.” Funding is allocated to invest in the control of communicable diseases and other notifiable conditions; chronic disease and injury prevention; environmental public health; maternal, child, and family health; access to and linkages with medical, oral, and behavioral health services; vital records; and other capabilities (e.g., public health emergency planning, communications, policy development and support, community partnership development, business competencies) ([RCW 43.70.515](#)). DOR predicts that the revenue from the tax on vapor products would increase funding deposited into the FPHS Account (personal communication, DOR, March 2021). For example, DOR predicts HB 1550 would deposit an additional \$10.7 million (\$5.4 million from the business and occupation surcharge; \$5.3 million from the excise tax) into the account for Fiscal Year (FY) 2022; \$20 million (\$8.5 million from the surcharge; \$11.5 million from the tax) for FY 2023; \$18.8 million (\$8.9 million from the surcharge; \$9.8 million from the tax) for FY 2024; and \$21.6 (\$9.4 million from the surcharge; \$12.2 million from the tax) for FY 2025 (unpublished data, DOR, March 2021).

However, while HB 1550 will increase funding available through the FPHS Account, under current law ([RCW 82.25.015](#)) the first \$12 million for 2019-2021 and 2021-2023 in this account must first fund “foundational public health services” ([RCW 43.70.515](#)). Tobacco/vapor product prevention is not currently included in the definition of “foundational health services.” Thus, additional funding for nicotine prevention and cessation is contingent on funding available in the FPHS Account beyond \$12 million. Tobacco and vapor product prevention as well as other substance use prevention and education programming receive percentage-capped funding from the vapor product tax revenue only after the first \$12 million is allocated to foundational health services (personal communication, DOH, March 2021). Beyond \$12 million, current law stipulates that 17% of funding be used to fund tobacco, vapor product, and nicotine control and prevention. HB 1550 would also allow funds to be used for cessation and stipulates that prevention and education measures should place an emphasis on community-based strategies, including programs that consider the disparate impacts of nicotine addiction on specific populations, including youth and racial or other disparities. However, given funding uses and allocation under the FPHS Account, it is unclear how much funding would be available for nicotine prevention and cessation.

Fifty percent of the next \$10 million in revenue from the tax on vapor products must be deposited into the Andy Hill Cancer Research Endowment Match Fund Account (Andy Hill CARE Fund) ([RCW 43.348](#)). All remaining funds are deposited into the FPHS Account. The Andy Hill CARE Fund was authorized by the legislature in 2015 to fund cancer prevention and treatment research in Washington State. The purpose of the Andy Hill CARE Fund is to guide the solicitation, selection, and award of grants to public and private entities to promote cancer

research in the state. Currently 50% of the revenue from the volume-based vapor product tax is deposited into the Andy Hill CARE Fund. DOR predicts that changes proposed in HB 1550 would decrease available funding for the Andy Hill CARE Fund. For example, DOR predicts HB 1550 would decrease funding by \$2.3 million in FY 2022; \$2.9 million in FY 2023; \$2.8 million in FY 2024; and \$5.3 million in FY 2025 (unpublished data, DOR, March 2021).

Since it is unknown exactly how much funding may be available in the FPHS Account and how funds will be allocated and used, this pathway was not included in the Logic Model.

Cessation

To date, e-cigarettes have not been approved by the FDA as an aid to quit smoking (i.e., a cessation device).^{79,80} The U.S. Department of Health and Human Services stated that, “so far, the research shows there is limited evidence that e-cigarettes are effective for helping smokers quit.”⁷⁹ Vapor product manufacturers may apply to have their product reviewed by FDA for approval as a cessation option. Due to confidentiality laws, the Division of Drug Information in the FDA’s Center for Drug Evaluation and Research (CDER) cannot provide information related to drug applications that may have been submitted to the agency (CDER, personal communication, September 2019), and analysts were unable to determine whether any vapor product manufacturers have applied to have their product reviewed as a cessation device.

Overall, there is mixed evidence that e-cigarettes provide opportunity for cessation for adult combustible cigarette smokers.^{6,26,80} While some studies suggest that e-cigarettes may be useful cessation tools or may help smokers decrease their use of combustible cigarettes, other studies have found that e-cigarette use is associated with a decreased likelihood of quitting combustible cigarettes and increased consumption of combustible cigarettes.³³⁻³⁶ A 2016 meta-analysis concluded that e-cigarettes, as they are currently being used, are actually associated with lower quit rates among adult combustible cigarette smokers.³⁶ A 2020 meta-analysis concluded that, “as consumer products, in observational studies, e-cigarettes were not associated with increased smoking cessation in the adult population. In [randomized control trials], provision of free e-cigarettes as a therapeutic intervention was associated with increased smoking cessation.”⁸⁰

National Health Interview Survey data (2014 to 2016) indicate the dominant pattern of e-cigarette use in adults is dual use of both combustible cigarettes and e-cigarettes.⁷⁴ As part of the interim guidance issued by CDC to address the outbreak EVALI, CDC recommended that, “adult smokers who are attempting to quit should use evidence-based smoking cessation treatments, including counseling and FDA-approved medications.”⁸¹ In sum, the National Academy of Sciences stated that, “the net public health effect, harm or benefit, of e-cigarettes depends on three factors: their effect on youth initiation of combustible tobacco products, their effect on adult cessation of combustible tobacco products, and their intrinsic toxicity.”²⁶ They concluded that “there would be net public health harm in the short and long terms if the products do not increase combustible tobacco cessation in adults.”²⁶

Since there is mixed evidence that e-cigarettes provide opportunity for combustible tobacco cessation in adults and since evidence suggests that most adolescents and young adults do not use e-cigarettes to quit smoking,^{48,74} we did not include this pathway in the logic model.

Annotated References

1. **Excise Tax.** Available at: <https://www.irs.gov/businesses/small-businesses-self-employed/excise-tax>. Accessed February 17, 2021.

This Internal Revenue Service (IRS) webpage defines excise taxes, as "taxes paid when purchases are made on a specific good [...] Excise taxes are often included in the price of the product. There are also excise taxes on activities."

2. **Family Smoking Prevention and Tobacco Control Act, 123 (2009).**

The 111th U.S. Congress found that "virtually all new users of tobacco products are under the minimum legal age to purchase such products" and that "tobacco advertising and marketing contribute significantly to the use of nicotine-containing tobacco products by adolescents." For this and other reasons, "It is in the public interest for Congress to enact legislation that provides the Food and Drug Administration with the authority to regulate tobacco products and the advertising and promotion of such products." Section Chapter IX--Tobacco Products, Section 907. Tobacco Product Standards (a)(1)(A) specifically bans the use of artificial or natural flavor (other than tobacco or menthol) or an herb or spice that is a characterizing flavor of the tobacco product or tobacco smoke in cigarettes. The full text of the Tobacco Control Act is available at <https://www.govinfo.gov/content/pkg/PLAW-111publ31/pdf/PLAW-111publ31.pdf>.

3. **Administration U.S. Food and Drug. Summary of the Deeming Final Rule. Silver Spring, Maryland: U.S. Food and Drug Administration.**

In this document the U.S. Food and Drug Administration (FDA) summarizes the Deeming Tobacco Products to be Subject to the Federal Food, Drug, and Cosmetic Act, as Amended by the Family Smoking Prevention and Tobacco Control Act; Restrictions on the Sale and Distribution of Tobacco Products and Required Warning Statements for Tobacco Products ('Deeming Rule'). The final rule was published on May 10, 2016. It extends the FDA's "tobacco product" authorities to "all other categories of tobacco products meeting the statutory definition of 'tobacco product' in the Federal Food, Drug, and Cosmetic Act (FD&C Act), except accessories of such products." The newly regulated products include currently marketed products (e.g., electronic cigarettes, cigars, waterpipe (hookah) tobacco) and future tobacco products. The Deeming Rule requires these tobacco products to comply with all provisions regarding "tobacco products" found in the FD&C Act and FDA regulations. The full text of the rule is available at <https://www.federalregister.gov/documents/2016/05/10/2016-10685/deeming-tobacco-products-to-be-subject-to-the-federal-food-drug-and-cosmetic-act-as-amended-by-the>.

4. **FDA News Release -- FDA takes new steps to address epidemic of youth e-cigarette use, including a historic action against more than 1,300 retailers and 5 major manufacturers for their roles perpetuating youth access [press release]. 2018.**

In September 2018, the U.S. Food and Drug Administration issued 1300 warning letters and fines to retailers who illegally sold JUUL and other e-cigarette products to minors. The FDA news release stated that this was the "largest coordinated enforcement effort in the FDA's history." FDA Commissioner Scott Gottlieb stated, "we see clear signs that youth use of electronic cigarettes has reached an epidemic proportion, and we must adjust certain aspects of our comprehensive strategy to stem this clear and present danger. This starts with the actions we're taking today to crack down on retail sales of e-cigarettes to minors." The FDA also issued

letters to the top five-selling e-cigarette brands (which comprise 97% of the U.S. e-cigarette market), including JUUL, Vuse, MarkTen XL, blu e-cigs, and Logic requiring each company "to submit to FDA within 60 days plans describing how they will address the widespread youth access and use of their product." The FDA also committed to increasing enforcement efforts for e-cigarette manufacturers and retailers.

5. FDA News Release -- Trump Administration Combating Epidemic of Youth E-Cigarette Use with Plan to Clear Market of Unauthorized, Non-Tobacco-Flavored E-Cigarette Products [press release]. Silver Spring, MD: U.S. Food and Drug Administration, 11 September 2019 2019.

This news release from the U.S. Food and Drug Administration (FDA) outlines the Trump Administration's announcement that as part of its ongoing work to address the epidemic of youth e-cigarette use, the agency will finalize a compliance policy that prioritizes enforcement of the premarket authorization requirements for non-tobacco-flavored e-cigarettes. Preliminary data from the National Youth Tobacco Survey show "that more than a quarter of high school students were current (past 30 day) e-cigarette users in 2019 and the overwhelming majority of youth e-cigarette users cited the use of popular fruit [65.9%] and menthol or mint [63.9%] flavors." Effective August 8, 2016, "all electronic nicotine delivery system (ENDS) products were expected to file premarket tobacco product applications with the FDA within two years. ENDS products currently on the market are not being legally marketed and are subject to government action. The compliance policy the FDA anticipates announcing in the coming weeks will outline enforcement policy addressing non-tobacco-flavored e-cigarette products that lack premarket authorization moving forward." FDA has issued more than 8,600 warning letters and more than 1,000 fines to retailers for sales of ENDS and their components to minors. Many e-liquid products resembling kid-friendly juice boxes, cereal, and candy have been removed from the market as the result of FDA warning letters--many written in collaboration with the Federal Trade Commission (FTC). On September 9, 2019, FDA issued a warning letter to JUUL Labs Inc. for "marketing unauthorized modified risk tobacco products by engaging in labeling, advertising, and/or other activities directed to consumers, including a presentation given to youth at a school."

6. FDA Statement--Statement from FDA Commissioner Scott Gottlieb, M.D., on proposed new steps to protect youth by preventing access to flavored tobacco products and banning menthol in cigarettes [press release]. 2018.

FDA Commissioner Scott Gottlieb outlines a "policy framework [that] reflects a re-doubling of the FDA's efforts to protect kids from all nicotine-containing products." He states that, "if we're to break the cycle of addiction to nicotine, preventing youth initiation on nicotine is a paramount imperative." He cites research showing that 90% of current adult smokers started smoking before 18 years of age, 95% started smoking before 21 years of age, and only 1% started smoking after 26 years of age. Research with the Centers for Disease Control and Prevention found that e-cigarette use among high school students increased 78% from 2017 to 2018, and 48% among middle school students- reversing prior trends from 2015 to 2017 suggesting that use was declining. To address these trends, FDA has taken a number of recent actions as part of their Youth Tobacco Prevention Plan, including increasing enforcement against retailers, targeting e-liquid manufacturers marketing to youth, working with eBay to remove products from their website, and launching "The Real Cost" Youth E-Cigarette Prevention Campaign. Dr. Gottlieb

stated, "I repeatedly said that, although we continue to believe that non-combustible tobacco products may provide an important opportunity to migrate adult smokers away from more harmful forms of nicotine delivery, these opportunities couldn't come at the expense of addicting a generation of kids to nicotine." This statement includes two directives from the FDA. First, FDA requires that all "flavored [electronic nicotine delivery systems] products (other than tobacco, mint, and menthol flavors or non-flavored products) must be sold in age-restricted, in-person locations and, if sold online, under heightened practices for age verification." Second, FDA issued a "Notice of Proposed Rulemaking that would seek to ban menthol in combustible tobacco products, including cigarettes and cigars." Data indicate that youth are more likely to use menthol cigarettes than any other group and that, "more than half (54 percent) of youth smokers ages 12-17 use menthol cigarettes, compared to less than one-third of smokers ages 35 and older." In addition, approximately 70% of African American youth use menthol cigarettes. In response, FDA is proposing a policy to ban flavors in cigars. Dr. Gottlieb emphasized that, "If youth trends don't move in the right direction, we will revisit all of these issues."

7. Surgeon General's Advisory on E-cigarette Use Among Youth [press release]. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2018.

In December 2018, the Office of the Surgeon General issued a statement "emphasizing the importance of protecting our children from a lifetime of nicotine addiction and associated health risks by immediately addressing the epidemic of youth e-cigarette use. The recent surge in e-cigarette use among youth, which has been fueled by new types of e-cigarettes that have recently entered the market, is a cause for great concern. We must take action now to protect the health of our nation's young people." The statement included background information that e-cigarette use increased dramatically from 2017 to 2018, and that e-cigarette aerosol can negatively impact health. The Surgeon General noted that e-cigarette aerosol and flavorings can expose users and bystanders to metals, volatile organic compounds, and ultrafine particles that can be inhaled deeply into the lungs. The statement also includes information about JUUL. The sale of JUUL increased 600% from 2016 to 2017, and the Surgeon General stated that "all JUUL e-cigarettes have a high level of nicotine. A typical JUUL cartridge or 'pod' contains about as much nicotine as a pack of 20 regular cigarettes." In addition, JUUL uses nicotine salts which allow nicotine to be inhaled more easily and with less irritation than tobacco products and other e-cigarettes. The statement noted that, "any e-cigarette use among young people is unsafe, even if they do not progress to future cigarette smoking."

8. ACT Relating to protecting youth from tobacco products and vapor products by increasing the minimum legal age of sale of tobacco and vapor products, Revised Code of Washington(2019).

In 2019, Washington State legislators passed Engrossed House Bill 1074, An act relating to protecting youth from tobacco products and vapor products by increasing the minimum legal age of sale of tobacco and vapor products. The legislation prohibits selling or giving tobacco or vapor products to a person under the age of 21 and permits the Governor to seek government-to-government consultations with tribes about raising the minimum legal age of sale in cigarette tax compacts. The law is effective January 1, 2020.

9. FDA News Release -- FDA launches its first youth e-cigarette prevention TV ads, plans new educational resources as agency approaches one-year anniversary of public education campaign [press release]. Silver Spring, MD, 22 July 2019 2019.

On July 22, 2019, the U.S. Food and Drug Administration announced the launch of its first e-cigarette prevention TV ads educating kids about the dangers of e-cigarette use. Part of FDA's "The Real Cost" Youth E-Cigarette Prevention Campaign, a \$60 million effort, the new ads highlight emerging science which indicates that "teens who vape are more likely to start smoking cigarettes, putting them at risk of a lifetime of addiction to smoking and related disease." Specifically, "compared with non-users, youth who use e-cigarettes are more likely to try conventional cigarettes in the future. This was also a conclusion reached in a National Academies of Sciences, Engineering, and Medicine report in 2018 on the Public Health Consequences of E-Cigarettes." The ads will run on television networks aimed at youth (e.g., TeenNick, CW, MTV), as well as on music streaming sites, social media networks, and other teen-focused media channels. Highlighted messages include, that e-cigarettes, like cigarettes, put youth at risk for addiction and other health consequences; nicotine can rewire the brain to crave more nicotine; and that e-cigarettes can contain dangerous chemicals.

10. Outbreak of Lung Injury Associated with E-cigarette Use, or Vaping. 2020; Available at: https://www.cdc.gov/tobacco/basic_information/e-cigarettes/severe-lung-disease.html. Accessed 20 January 2020.

In 2019, CDC, U.S. Food and Drug Administration, state and local health departments, and other clinical and public health partners began investigating outbreaks of severe pulmonary disease associated with e-cigarette use--i.e., E-cigarette, or Vaping, Associated Lung Injury (EVALI). "As of January 14, 2020, a total of 2,668 hospitalized EVALI cases or deaths have been reported to CDC from all 50 states, the District of Columbia, and two U.S. territories (Puerto Rico and U.S. Virgin Islands)." Sixty deaths have been confirmed in 27 states and the District of Columbia (as of January 14, 2020); Washington State is not among the states that have reported EVALI patient death(s). "The median age of deceased patients was 51 years and ranged from 15-75 years (as of January 14, 2020)." Of the total number of EVALI cases with available data (as of January 14, 2020): 66% were male; 15% were under 18 years old; 37% were 18 to 24 years old; 24% were 25 to 34 years old; and 24% were 35 years or older. The median age of patients was 24 years (range from 12-85 years). "Data from emergency department (ED) visits suggest that the EVALI outbreak began in June 2019, and cases have been declining since a peak in September. Overall, data suggest a period of gradual increase in ED visits associated with e-cigarette use since 2017, followed by a sharp rise in June 2019. The CDC notes, "While ED visits associated with possible EVALI have declined [since a peak in September 2019], they have not returned to levels before June 2019 and EVALI remains a concern." National data show that certain groups of EVALI patients (i.e., those with cardiac disease, chronic pulmonary disease, and diabetes as well as older adults) are more likely to be rehospitalized or die. CDC reported, "2,022 hospitalized patients had data on substance use, of whom (as of January 14, 2020): 82% reported using THC-containing products; 33% reported exclusive use of THC-containing products." Meanwhile, "57% reported using nicotine-containing products; 14% reported exclusive use of nicotine containing products." Of those EVALI patients who reported using nicotine-containing products, 54% provided data on product source (as of January 7, 2020): 69% reported acquiring products only from commercial sources; 17% reported acquiring products only from informal sources; and 15% reported acquiring products from both

commercial and informal sources." Among younger EVALI patients (aged 13 to 17 years), 94% of acquired THC-containing products only from informal sources (versus 62% of those aged 45 years or older) and 42% acquired nicotine-containing products only from informal sources (versus 12% of those aged 45 years or older) (as of January 7, 2020). Patient exposure data indicate: "Vitamin E acetate has been identified as a chemical of concern among people with EVALI," and "THC is present in most of the samples tested by FDA to date, and most patients report a history of using THC-containing products." As of January 7, 2020, "The latest national and state findings suggest THC-containing e-cigarette, or vaping, products, particularly from informal sources like friends, family, or in-person or online dealers, are linked to most of the cases and play a major role in the outbreak. Among other recommendations, CDC recommends that youth and young adults, women who are pregnant, and adults who do not currently use tobacco products not use e-cigarette products.

11. Bogan Sharon. First Case of Vaping-Related Lung Illness Confirmed in King County. Seattle, Washington: Public Health - Seattle & King County; 2019.

This article from Public Health - Seattle & King County (PHSKC) staff reported the first confirmed case of severe lung disease associated with e-cigarettes in Washington State. The patient (male, late teens) was hospitalized in August for fever, cough, and shortness of breath. He was treated in an intensive care unit for 5 days before being released to recover at home. The teenager reported vaping nicotine with propylene glycol as well as saffron, but PHSKC's investigation is ongoing and details about the type of vaping device, where the products were obtained or if other substances were also used were unknown at the point of publication. Dr. Jeff Duchin, Health Officer for PHSKC, noted that "e-cigarettes and vaping are not safe [...] Youth, young adults and pregnant women should never use e-cigarettes or vapes." Duchin also noted that "[a]lthough e-cigarettes are not approved as a cigarette smoking cessation method, we are aware that some people use them in this way. People who want to quit or reduce cigarette smoking should consult with their health care provider for effective treatment options."

12. Inslee Jay. Executive Order 19-03 Addressing the Vaping Use Public Health Crisis. In: Governor WSOot, ed. 27 September 2019 ed. Olympia, Washington 2019.

Governor Inslee issued Executive Order 19-03, Addressing the Vaping Use Public Health Crisis [EO] on September 27, 2019. The text acknowledges that vapor products containing nicotine are the most commonly used nicotine products in Washington among youth and that the appeal of flavors, and associated advertising targeting youth, are contributing to the dramatic increase in youth vaping. The EO highlights "in 2019, an outbreak of a lung injury emerged in previously health individuals who had recently vaped THC and/or nicotine vapor products, and the cause of the injury is not yet known." In response, the Governor directed the Washington State Department of Health and Washington State Liquor and Cannabis Board to each take actions to address the this public health crisis. See full list of action items in the EO text.

13. Vapor Products and Flavors, Washington Administrative Code(2019).

Chapter 246-80 WAC Vapor Products and Flavors documents the Washington State Board of Health's emergency rules. The rules will be in effect from October 10, 2019 for 120 days.

14. **Vapor Products and Flavors. Rulemaking 2019; Available at: <https://sboh.wa.gov/Rulemaking/CurrentRulesandActivity/VaporProductsandFlavors>. Accessed January 2020, 2020.**

This Washington State Board of Health (SBOH) webpage provides an overview of SBOH's emergency rulemaking related to vapor products and flavors. It provides links to emergency rules.

15. **Health Washington State Board of. WSR 19-21-050 Emergency Rules In: Health WSBo, ed. Olympia, Washington2019.**

Washington State Register (WSR) 19-21-050 announces the creation of Chapter 246-80 WAC, Vapor products and flavors.

16. **Health Washington State Board of. WSR 19-24-001 Emergency Rules In: Health WSBo, ed. 20 November 2019 ed. Olympia, Washington2019.**

Washington State Register (WSR) 19-24-001 announces the creation of WAC 246-80-021, which bans the sale of vapor products containing vitamin E acetate.

17. **Vaping Associated Lung Injury. 2020; Available at: <https://www.doh.wa.gov/Emergencies/VapingAssociatedLungInjury>. Accessed 15 January 2020.**

Washington State Department of Health is working with local health jurisdictions, CDC, and FDA to investigate an outbreak of lung injury associated with e-cigarettes and vapor products (e.g., JUULs, e-cigarettes, e-cigs, vapes, e-hookahs, vape pens, mods, tanks, or electronic nicotine delivery systems). As of January 15, 2020, Washington State data show: 22% of patients are 10 to 19 years old; 26% of patients are 20 to 29 years old; 30% of patients are 30 to 39 years old; 13% of patients are 40 to 49 years old; 9% of patients are 70 to 79 years old; no reported patients are 50 to 69 years of age." The latest national findings suggest THC-containing vapor products, particularly those from informal sources like friends, family, or in-person or online dealers, are linked to most patients with vaping-associated lung injury and play a major role in the outbreak. In addition, vitamin E acetate, an additive in some THC-containing vapor products, is closely associated with vaping-associated lung injury." Nationally, about 13% of patients report exclusively using non-THC vapor products. In Washington, 39% of patients report only using non-THC vapor products. Meanwhile, 13% of Washington patients report using THC products only; 26% report using THC and nicotine products; 4% report using "other" products; and product use data is unknown for two patients and not yet released for two patients. DOH states, "It is unclear if these patients are non fully disclosing THC use, are being exposed to a substance that is also in THC products, or have lung injury unrelated to vaping. Additionally, it is possible that there may be multiple substances in multiple vapor products that cause lung injury." As there are many different substances and product sources that are being investigated, and there may be more than one cause, DOH recommends, "the best way for people to ensure they are not at risk while the investigation continues is to consider refraining from the use of all e-cigarette, or vaping, products."

18. **Tobacco 21. 2021; Available at: <https://www.fda.gov/tobacco-products/retail-sales-tobacco-products/tobacco-21>. Accessed 3/25/2021.**

The Federal Food, Drug, and Cosmetic Act was modified on December 20, 2019 to raise the federal minimum age for sale of tobacco products from 18 years old to 21 years old. The change applied to all tobacco products, including cigarettes, cigars, and e-cigarettes, and was effective immediately.

19. FDA Finalizes Enforcement Policy on Unauthorized Flavored Cartridge-Based E-Cigarettes that Appeal to Children, Including Fruit and Mint [press release]. 2020.

This press release announced FDA enforcement efforts on unauthorized flavored e-cigarettes that appeal to youth.

20. Organization World Health. Smoking and COVID-19: Scientific brief. 2020.

The World Health Organization (WHO) conducted a review of literature to evaluate the association between smoking and COVID-19. They identified 34 peer-reviewed journal articles published before May 2020, including 26 observational studies, 8 meta-analyses, and qualitative primary research. Research has shown that 1.4% to 18.5% of individuals hospitalized for COVID-19 were smokers. A meta-analyses of 7 studies “found a statistically significant association between smoking and severity of COVID-19 outcomes amongst patients.” Other studies found a statistically significant association between smoking status and COVID-19 disease severity, admission to an Intensive Care Unit, ventilator use, and death. WHO concluded that, “available evidence suggests that smoking is associated with increased severity of disease and death in hospitalized COVID-19 patients.”

21. Huang J. , Taura J. , Chaloupka F.J. The impact of price and tobacco control policies on the demand for electronic nicotine delivery systems. *Tobacco Control*. 2014;23.

Huang et al. estimate the own and cross-price elasticity of demand for e-cigarettes and examine the impact of cigarette prices and smoke-free policies on e-cigarette sales. Authors used quarterly e-cigarette prices and sales and those of conventional cigarettes obtained from Nielsen Retail Scanner Data for the period 2009 to 2012. They used fixed-effects models to estimate own- and cross-price elasticity of demand. "Estimated own price elasticities for disposable e-cigarettes centered around -1.2 , while those for reusable e-cigarettes were approximately -1.9 ." In other words, a 10% increase in price would decrease sales by 12% for disposable e-cigarettes and 19% for rechargeable e-cigarettes, respectively. Furthermore, results suggest disposable e-cigarettes may be an emerging substitute for rechargeable e-cigarettes (i.e., a 10% increase in price of rechargeable e-cigarettes increased sales of disposable products by 5%). Authors concluded, increasing the retail prices of e-cigarettes (e.g., imposing taxes) could potentially lead to significant reductions in e-cigarette sales, while variations in tax policy by product type could lead to substitution between product categories.

22. Pesko M.F., Huang J., Johnston L.D., et al. E-cigarette price sensitivity among middle- and highschool students: evidence from monitoring the future. *Addiction*. 2017;113:896-906.

Pesko et al. estimate the association between e-cigarette (disposable and refill) retail prices and use of e-cigarettes among American middle- and high-school students in 2014 and 2015 using the Monitoring the Future (MTF) data. Participants included 24,370 middle (i.e., 8th grade) and high school (i.e., 10th and 12th grade) students who participated in the nationally representative MTF Survey in 2014 and 2015. Authors controlled for socio-demographic characteristics,

cigarette prices, tobacco control policies, market fixed effects, and year-quarter fixed effects. They used self-reported e-cigarette use over the last 30 days. E-cigarette and cigarette price data were collected from store scanner data compiled by the Nielsen Company and is inclusive of mass stores, drug stores, and grocery stores. Authors state "respondents may pay different prices due to, among other things, price distortions caused by inability to legally purchase e-cigarettes in stores and brand selection." Among participants, 13.9% had vaped in the past 30 days, with an average number of days vaped of 7.5 days (within the past 30 days). "The average price in the sample was \$8.35 for a single disposable e-cigarette, \$3.07 per cartridge for e-liquid refills and \$5.87 for a pack of cigarettes." The resulting model estimated that "a 10% increase in e-cigarette disposable prices is associated with a reduction in the number of days vaping among e-cigarette users by approximately 9.7% [95% confidence interval (CI) = 17.7 to 1.8%; P = 0.02] and is associated with a reduction in the number of days vaping by the full sample by approximately 17.9% (95% CI = 31.5 to 4.2%; P = 0.01)." Additionally, "the corresponding marginal effects for these estimates (unreported) shows that a \$1 increase in e-cigarette prices is associated with a reduction in conditional e-cigarette demand by 0.87 days (21.8% of the mean) and reduces total demand by 0.22 days (21.4% of the mean)." Refill e-cigarettes were not statistically significant predictors of vaping. Neither were cigarette prices associated significantly with e-cigarette use (regardless of the e-cigarette price used), but authors note estimates were imprecise. Authors conclude, "higher e-cigarette disposable prices appear to be associated with reduced e-cigarette use among adolescents in the US."

23. Yao T. , Sung H.Y., Huang J., et al. The impact of e-cigarette and cigarette prices on e-cigarette and cigarette sales in California. *Preventive Medicine Reports*. 2020;20:101244.

Yao et al. estimated the impact of e-cigarette and cigarette prices on e-cigarette and cigarette sales in California. Authors used 2012-2017 Nielsen Retail Scanner Data to construct prices (i.e., for disposable e-cigarettes, reusable e-cigarettes, and cigarettes), per capita sales per year, quarter, and Nielsen scan track market for California. Authors controlled for the percent of the California population covered by 100% smoke-free air laws in each year/quarter. They used a fixed-effects model to estimate the impact of prices on sales for each respective product (disposable e-cigarettes, reusable e-cigarettes, and cigarettes). Authors "estimated that own-price elasticity [i.e., the % change in quantity demanded in response to a % change in price] was - 0.37 for disposable e-cigarettes, 0.20 for reusable e-cigarettes, and 0.21 for cigarettes, which indicates that when price increases by 1%, per capita sales would decrease by 0.37% for disposable e-cigarettes, 0.20% for reusable e-cigarettes, and 0.21% for cigarettes." When assessing cross-price elasticities [i.e., the % change in quantity demanded for one product in response to a % change in price of another product], resulting positive cross-price elasticity for reusable e-cigarettes with respect to cigarette prices, indicates reusable e-cigarettes are substitutes for cigarettes. However, they found "no statistically significant associations were found between cigarette sales and disposable or reusable e-cigarette prices in the cigarette demand model," meaning cigarettes were not substitutes for reusable e-cigarettes among the California study population. Finally, "the cross-price elasticity of disposable e-cigarette sales in response to reusable e-cigarette prices was positive and statistically significant at 0.14, indicating that disposable e-cigarettes are substitutes for reusable cigarettes. Although reusable e-cigarette sales were negatively associated with disposable e-cigarette prices, this association was not statistically significant." Authors note that estimated own-price elasticity of demand for disposable (-0.4) and reusable (-0.2) e-cigarettes are lower

than previous estimates using older data (2009-2012), which may indicate they have become less elastic as users developed nicotine dependency. Limitations of this study include lack of data on JUUL products, which did not come onto the market until 4th quarter 2016. JUUL became the most popular e-cigarette brand in 2017 and comprised a large share of the e-cigarette market (72% as of September 2018) until September 2019 following the U.S. FDA's warning that the company was illegally marketing its products as a safer alternative to cigarettes. Another limitation of the study is retail data available through Nielsen does not include online or vape shop sales of e-cigarettes, which were estimated to represent 30% and 23%, respectively, of the total e-cigarette in 2014. Overall, evidence suggests raising prices can reduce sales of these products. However, the magnitude of effects would differ by e-cigarette product type.

24. Corrigan J.R. , Hackenberry B.N. , Lambert V.C., et al. Estimating the price elasticity of demand for JUUL E-cigarettes among teens. *Drug and Alcohol Dependence*. 2021;218(108406).

Corrigan et al. used results of an experimental auction attended by teen nicotine users and nonusers to estimate the price elasticity of demand for JUUL. Participants were recruited from Susquehanna University (N=112) and the University of South Carolina (N=188) between October 2018 and March 2019. Of the 300 18 and 19 year-old participants (ID verified age), 58% were current nicotine users (i.e., had used cigarettes or e-cigarettes within the last 30 days). Of these 117 used only e-cigarettes, 5 used only cigarettes, and 53 were dual users. One hundred and twenty-five participants were nonusers. Each participant received \$20 for taking part in the 20-minute study. The study auction consisted of 10 tobacco products, which varied by product type (i.e., e-cigarette, conventional cigarette, heated tobacco product), flavor, brand, and nicotine level. Participants also evaluated a Starbucks gift card and a JUUL starter kit (i.e., device and 4 flavored pods [mint, creme brulee, tobacco, mango]). Rules of the auction were established so that "a participant could do no better than to submit a bid equal to what they were truly willing to pay for a product [...] because the participant's bid could not influence the price they would pay if they won the auction, meaning there was no incentive to submit a low bid in the hope of getting a better deal." Authors used responses to create demand curves for a JUUL kit among nicotine users and nonusers. Overall, they found among the study population "a 10% increase in price leads to as much as a 24% reduction in e-cigarette demand among teens currently using nicotine, and as much as a 45% reduction among teens who are currently not using nicotine." Authors compared results to a similar experimental auction of a Blu e-cigarette among adults (average age 42 years). They found the linear price elasticity of demand among adult auction winners was -0.56 (95% CI [-0.60, -0.53]). By comparison, the linear price elasticity of demand for this teen sample was -0.78 (95% CI [-0.80, -0.76]) among users and -1.49 (95% CI [-1.54, -1.44]). Overall, "results suggest that teen nonusers are dramatically more price sensitive than teen nicotine users, who are, in turn, somewhat more price sensitive than adult smokers who are not current e-cigarette users." Authors conclude, "High e-cigarette taxes may dissuade relatively few older adult cigarette smokers from switching to e-cigarettes, but at the same time be highly effective at preventing teens from becoming e-cigarette users in the first place."

25. Pisinger Charlotta, Dossing Martin. A systematic review of health effects of electronic cigarettes. *Preventive Medicine*. 2014;69:248.

Pisinger and Døssing conducted a systematic review of the literature on the health consequences of vaping products published before August 14, 2014. The authors identified 76 studies which

met their inclusion criteria. They found that 34% of the studies' authors had a conflict of interest (e.g. the study was funded or somehow influenced by electronic cigarette manufacturers or consultants for manufacturers of medicinal smoking cessation therapy). Many studies found that product labels did not show the concentrations of solvents and flavoring and that products labeled nicotine free were sometimes found to actually contain nicotine in high concentrations. There was also variability in product concentrations from cartridge-to-cartridge. The authors conclude that the studies had many methodological problems and that the body of evidence is inconsistent, lack long-term follow up, and don't allow any firm conclusion on the safety of vaping products. They conclude that these 76 studies indicate that electronic cigarettes cannot be regarded as safe. The available evidence does indicate that at least some vaping products are toxic to human cells and contain toxic compounds such as metals, traces of carcinogenic nitrosamines, formaldehyde, mercury, and other potentially harmful components. Vaping was associated with significant airway and lung obstruction in the short term and other adverse effects in the mouth/throat. Some studies indicate that vaping may have less adverse effects or result in less exposure to harmful substances than combustible cigarettes. Some studies suggest that electronic cigarettes may be useful as a smoking reduction/cessation aid, but the evidence on their efficacy is conflicting.

26. Sciences National Academy of. *Public Health Consequences of E-Cigarettes.* Washington, D.C.: The National Academies Press; 2018.

The U.S. Food and Drug Administration requested the National Academy of Sciences complete a report about the health impacts of e-cigarettes. As part of this white paper, the National Academy of Sciences evaluated existing published literature to determine whether there was conclusive, substantial, moderate, limited, insufficient, or no available evidence to determine the link between e-cigarette use and health outcomes. They stated that, "the net public health effect, harm or benefit, or e-cigarettes depends on three factors: their effect on youth initiation of combustible tobacco products, their effect on adult cessation of combustible tobacco products, and their intrinsic toxicity." E-cigarette use among youth and young adults has increased, and in 2016, e-cigarette use was higher than cigarette smoking or use of any other tobacco product. Use was also higher among boys and Hispanic and non-Hispanic whites. They reached 9 conclusions about the make-up of e-cigarettes. They found conclusive evidence that: 1) E-cigarette use increases airborne concentrations of particulate matter and nicotine in indoor environments. 2) Exposure to nicotine from e-cigarette use is variable and depends on product characteristics and operation. 3) E-cigarettes contain and emit numerous potentially toxic substances in addition to nicotine. 4) The number, quantity, and characteristics of potentially toxic substances in e-cigarettes are highly variable and depend on product characteristics and operation. They found substantial evidence that: 5) Nicotine intake from e-cigarettes among experienced adult e-cigarette users is comparable to that from combustible tobacco cigarettes. 6) Under typical use, except for nicotine, there is lower exposure to potentially toxic substances from e-cigarettes compared to combustible tobacco cigarettes. 7) E-cigarettes contain metals. They found limited evidence that: 8) E-cigarette use increases levels of nicotine and other chemicals on indoor surfaces. 9) the number of metals in e-cigarettes could be greater than the number of metals in combustible cigarettes. The National Academy of Sciences also made 26 conclusions about the impact of e-cigarettes on health outcomes. They concluded that, "the implications for long-term effects on morbidity and mortality are not yet clear. Use of e-cigarettes instead of combustible tobacco cigarettes by those with existing respiratory disease might be less harmful." They found

conclusive evidence that: 1) E-cigarette devices can explode and cause burns and injuries. 2) Intentional or accidental exposure to e-liquids can result in seizures, anoxic brain injury, vomiting, and lactic acidosis, among other effects. 3) Intentionally or unintentionally drinking or injecting e-liquids can be fatal. They found substantial evidence that: 4) Components of e-cigarettes can promote formation of reactive oxygen species/oxidative stress. 4) E-cigarette use results in symptoms of dependence on e-cigarettes. 5) E-cigarette use increases heart rate shortly after nicotine intake. 6) Chemicals in e-cigarettes are capable of causing DNA damage and mutagenesis, suggesting the possibility that long-term exposure could increase risk of cancer and adverse reproductive outcomes. Related to initiation and cessation, they found 7 conclusions. They found mixed evidence that, "while e-cigarettes might cause youth who use them to transition to use of combustible tobacco products, they might increase adult cessation of combustible tobacco products." They found substantial evidence that "e-cigarette use increases risk of ever using combustible tobacco cigarettes among youth and young adults." Overall, the National Academy of Sciences found that the evidence across a range of outcomes suggests that, "e-cigarettes pose less risk to an individual than combustible tobacco cigarettes." They also concluded that "there would be net public health harm in the short and long terms if the products do not increase combustible tobacco cessation in adults."

27. Hocharoen Chanalee. An evaluation of potential harm of electronic cigarette aerosol exposures and directions for research and regulation. In: Taft D, ed: ProQuest Dissertations Publishing; 2015.

Hocharoen conducted a systematic review of the literature on electronic cigarettes published between January 1, 2009 and January 31, 2015. Thirty-nine articles met the inclusion criteria. Three of these studies examined inflammatory markers, cytokines, and chemokines, all of which found that interleukins (cellular messengers for immune response) increased with electronic cigarette exposure. One study found that interleukin 6 decreased with e-cigarette exposure. Seven studies examined cytotoxicity (cell toxicity) or mutagenicity (ability to cause genetic mutations). These studies looked at the impacts of e-vapors of liquids on lung, throat, and mouth specific embryonic stem cells, and various fibroblasts. Six of these seven studies found cytotoxic effects, decreased cell viability, changes in cell morphology, reduced ATP detection, and cell mutagenicity for at least one of the measured flavors or e-liquid components. The seventh study found no cytotoxicity from e-liquids for epithelial carcinoma cells or Chinese Hamster ovary cells. The author concludes that cell viability is affected by e-cigarettes and that vapor products sometimes contain "carcinogens, metals, and other potentially harmful constituents." The author notes that while physiological effects of e-cigarettes have been found in the literature, potential adverse long-term effects have not been studied.

28. General Office of the Surgeon. E-Cigarette Use Among Youth and Young Adults: A Report of the Surgeon General. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office of Smoking and Health; 2016.

This report was prepared by the Centers for Disease Control and Prevention's National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health. It focused on examining the research around the epidemiology and health effects of e-cigarette use among youth and young adults in the United States. They note that, "the initial drafts of the chapters were written by 27 experts who were selected for their knowledge of the topics addressed. These

contributions are summarized in five chapters that were evaluated by approximately 30 peer reviewers. After peer review, the entire manuscript was sent to more than 20 scientists and other experts, who examined it for its scientific integrity." The chapters outline the following topic areas: (1) historical background, (2) patterns of e-cigarette use among U.S. youth and young adults, (3) health effects of e-cigarette use among U.S. youth and young adults, (4) activities of e-cigarette companies, and (5) e-cigarette policy and practice implications.

29. Center Washington Poison. 2017 Annual Toxic Trend Report: Nicotine and E-Cigarette. 2017.

This brief report from the Washington Poison Center provides summary data from calls about nicotine exposure among children 0 to 12 years of age. From 2011 to 2017, the Washington Poison Center received 2,966 total cases related to nicotine exposure. The most cases occurred in 2015, with 521 total cases of nicotine exposure. In 2017, the Center had 440 cases of nicotine exposure and 373 (84.8%) cases were among children 0-5 years of age. About half of nicotine exposures come from cigarette/cigar exposure, 22% are related to e-cigarettes, and 22% are related to chewing tobacco. Children are primarily exposed through ingestion (94.5% of cases are due to ingestion), and common symptoms of nicotine exposure include vomiting, coughing/choking, drowsiness/lethargy, and pallor. Washington Poison Center noted that exposure reporting is voluntary, and that these numbers likely underrepresent nicotine exposure.

30. Rubinstein M.L., Delucchi K., Benowitz N.L., et al. Adolescent Exposure to Toxic Volatile Organic Chemicals from E-Cigarettes. *Pediatrics*. 2018;141(4).

Rubinstein et al. analyzed urine and saliva samples from adolescents aged 13-18 years old who use electronic cigarettes to evaluate the presence of volatile organic compounds. More adolescents use e-cigarettes than cigarettes, and chemicals found in e-cigarettes are known to be harmful to human health. However, the authors noted that, "there are no data on toxicant exposure in adolescent e-cigarette users. However, there is great concern because exposure to toxicants during adolescence may result in greater harm than exposure in adulthood, given vulnerability to the acute and chronic effects of toxicants in general and from their cumulative exposure if started early." This study included adolescents participating in a larger longitudinal study of the effects of e-cigarettes on adolescents in the San Francisco Bay Area. Adolescents who used e-cigarettes were scheduled for a baseline appointment within 24 hours of use and provided saliva and urine samples for analysis. Saliva samples were analyzed for cotinine, a metabolite of nicotine. Urine samples were analyzed for NNAL (a potent carcinogen) and eight volatile organic compounds that are toxic environmental or tobacco smoke constituents. They used use categories based on self-report as well as chemical levels so that, "conservative criteria for group definitions meant that the e-cigarette-only group was clearly differentiated from the dual user group, and any [volatile organic compounds] found in the e-cigarette-only group could be clearly attributed to e-cigarette use." Based on their criteria, samples were analyzed for 67 e-cigarette-only users, 16 dual users, and 20 controls. They found that the presence of 5 volatile organic compounds was significantly higher in e-cigarette-only users compared with controls ($p < .05$ for all compounds), but lower than in dual-users. For e-cigarette-only users, levels were statistically significantly higher for users that used e-cigarettes with nicotine all or some of the time and for users that reported more sessions of e-cigarette use per day. They also found that "levels of 3 other significant and likely toxic [volatile organic compounds] were just as high in users of nonnicotine products as in those using nicotine." The authors concluded, "Adolescent e-

cigarette-only users had levels of 5 [volatile organic compound] toxicants detected in their urine in quantities up to 3 times greater than in matched controls...levels of toxicant exposure in dual users were up to 3 times higher than in those who used only e-cigarettes." Many of these compounds are known carcinogens.

31. Alzahrani T., Pena I., Temesgen N., et al. Association Between Electronic Cigarette Use and Myocardial Infarction. *American Journal of Preventive Medicine*. 2018;55(4):455-461.

Alzahrani et al. evaluated 2014 and 2016 National Health Interview Survey data to determine whether electronic cigarette use could increase the risk of myocardial infarction. This was the first study to examine the relationship between e-cigarette use and heart attack. E-cigarette use has been shown to stimulate similar reactions as traditional cigarette use in otherwise healthy individuals, including endothelial dysfunction, oxidative stress, inflammation, platelet activation, and activation of the sympathetic nervous system. Interviewees were classified as never, former, and current e-cigarette and cigarette users. However, the definition of former use was not consistent between e-cigarette users and cigarette users. Based on NHIS responses, 25.8% of current e-cigarette users were former smokers and 66.2% of current e-cigarette users were also current cigarette smokers. Overall, the authors found that daily e-cigarette use was independently associated with increased odds of myocardial infarction (OR= 1.79, 95% CI= 1.20, 2.66, p-value= 0.004). Former and some day e-cigarette use were not associated with increased risk of heart attack. Former, some day, and current cigarette use were all associated with increased risk of heart attack. The authors also found that, "dual use of e-cigarettes and conventional cigarettes appears to be more dangerous than using either product alone." The authors state that their study likely underestimates the increased risk of heart attack from using e-cigarettes, and that more research is needed to fully understand the health impacts of former or some day e-cigarette use. They state that, "it is not known when the [myocardial infarctions] occurred relative to e-cigarette use, and it is likely that some of the heart attacks subjects reported occurred before e-cigarettes became available in the U.S. (around 2009). This situation will bias the [odds ratio] estimates toward the null, meaning that the study results likely underestimate the true risks associated with e-cigarette use."

32. Clapp P., Lavrich K., Reidel B., et al. The E-Cigarette Flavoring Cinnamaldehyde Suppresses Mitochondrial Function and Transiently Impairs Cilia Beat Frequency in Human Bronchial Epithelial Cells. Paper presented at: Epithelial Function in Health and Disease- Poster Discussion Session; May 23, 2018, 2018; San Diego, California.

In this abstract, Clapp et al. explain that compounds in cigarettes impair mitochondrial function and reduce cilia beat frequency, impairing lung function. They note that cinnamaldehyde, which is commonly used to flavor e-cigarette products, has similar structural properties to compounds in cigarettes. They determined the content of cinnamaldehyde in e-cigarette products and exposed human bronchial epithelial cells to various levels to evaluate a dose-response relationship. Overall, the authors concluded, "data suggest that cinnamaldehyde, a ubiquitous flavoring agent commonly used in e-cigarettes, adducts to mitochondrial proteins, disrupts mitochondrial function, and significantly reduces intracellular ATP levels, which correlates with impaired [cilia beat frequency] in airway epithelial cells...inhalational exposures of cinnamaldehyde may increase the risk of respiratory infections in e-cigarette users."

33. **Gmel Gerhard, Baggio Stéphanie, Mohler-Kuo Meichun, et al. E- cigarette use in young Swiss men: is vaping an effective way of reducing or quitting smoking? *Swiss medical weekly*. 2016;146:w14271.**

Gmel et al. summarize the current evidence on the impact of e-cigarettes on combustible cigarette usage, noting that the literature is conflicting—with some studies finding that vaping is associated with using fewer cigarettes but with being less likely to completely quit smoking combustible cigarettes, and other studies finding an increase in combustible cigarette usage and decreased likelihood of quitting, and still other studies finding that e-cigarettes were associated with more quit attempts and continued abstinence than NRT or using no aid. The authors used data from the Cohort Study on Substance Use Risk Factors in Switzerland. While 7,556 participants (all young men) provided consent to participate, 79.2% (n=5,987) completed the baseline questionnaire and 79.7% (n=6,020) completed the follow-up questionnaire. A total of 91.5% of the baseline respondents (n=5,476) also completed the follow-up questionnaire. Among those who did not smoke at baseline, those who were vaping at follow-up were more likely to start smoking and to become occasional or daily smokers at follow-up than were non-vapers. Among those who were occasional smokers at baseline, non-vapers were more likely to become non-smokers and less likely to become daily smokers than vapers. Among those who did not smoke at baseline, vapers were 6 times more likely to be occasional smokers and 12 times more likely to be daily smokers at follow-up than non-vapers. Among non-smokers at baseline, vapers smoked significantly more (10 times more) cigarettes weekly at follow-up than did non-vapers. Weekly cigarette use increased between baseline and follow-up for occasional smokers and decreased for daily smokers but these changes were not significantly between vapers and non-vapers.

34. **Grace Randolph C., Kivell Bronwyn M., Laugesen Murray. Estimating cross- price elasticity of e- cigarettes using a simulated demand procedure. *Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco*. 2015;17(5):592.**

Grace et al. collected data from a convenience sample of 210 daily smokers in New Zealand who were 18 years of age or older and who had no intention to quit smoking before January 1, 2013. They excluded any smokers who had ever used e-cigarettes. They interviewed participants between February and March of 2013 (response rate not noted). The researchers had participants complete a written survey and three additional validated surveys, complete the Cigarette Purchase Task (CPT), sample an e-cigarette, and then answer questions about their intentions to purchase e-cigarettes and their regular tobacco product. The CPT is used to measure demand for tobacco products across a range of prices. The authors used the CPT completed before sampling the e-cigarette as a baseline to determine the demand for combustible cigarettes in the absence of e-cigarettes. The participants also indicated their intentions to purchase e-cigarettes and combustible cigarettes after trying the e-cigarette. The authors found that the simulated demand for e-cigarettes increased as the price of regular cigarettes increased, with an average cross-price elasticity of 0.16 (indicating that a 10% increase in the cost of combustible cigarettes was associated with a 1.6% increase in the demand for e-cigarettes). However, the simulation also found that the low-cost availability of e-cigarettes did not decrease the demand for regular cigarettes at a higher price and that a significantly lower proportion of participants said that they would quit smoking tobacco completely if e-cigarettes were available than if they were not. This finding suggests that the availability of low-priced e-cigarettes could actually encourage people who would otherwise have quit smoking completely as a result of raising tobacco prices to

instead continue to use combustible cigarettes perhaps in tandem with lower-cost e-cigarettes. So, while the study found that smokers may substitute e-cigarettes for combustible cigarettes as the cost of the later increases (with the cost of the former staying low), low-cost e-cigarette availability may actually discourage combustible cigarette smokers from quitting entirely as combustible cigarette prices increase.

35. Rahman M. A., Hann N., Wilson A., et al. E- Cigarettes and Smoking Cessation: Evidence from a Systematic Review and Meta- Analysis. *PLoS One*. Vol 102015.

Rahman et al. conducted a systematic review of the literature on combustible cigarette consumption or cessation after the use of e-cigarettes. Six studies met their inclusion criteria. They found that e-cigarettes with nicotine were more effective as a cessation tool than those without nicotine. The authors pooled data from two randomized control trials and found a risk ratio of 2.29 (95% CI 1.05-4.97). They also found that use of e-cigarettes was associated with smoking cessation and reduction in the number of cigarettes used—though three of the six studies did not include a control group. The authors note that they were only able to consider the efficacy of nicotine vs. non-nicotine e-cigarettes and were not able to compare the efficacy of e-cigarettes to other cessation interventions.

36. Kalkhoran Sara, Glantz Stanton A. E-cigarettes and smoking cessation in real-world and clinical settings: a systematic review and meta-analysis. *The Lancet Respiratory Medicine*. 2016;4(2):116-128.

Kalkhoran et al. conducted a systematic review and meta-analysis to evaluate the association between e-cigarette use and combustible cigarette cessation among adults. Thirty-eight studies met their inclusion criteria for the systematic review, 20 of which had control groups and were included in the meta-analysis. They found that the odds of combustible cigarette cessation among those who used e-cigarettes was 28% lower than for those who did not use e-cigarettes (OR 0.72 [95% CI 0.57-0.91]). When the authors only included studies of smokers with an interest in quitting, they did not find a significant difference from the overall findings. The authors conclude that e-cigarettes, as they are currently being used, are associated with lower quit rates among combustible cigarette smokers.

37. Watkins S. L., Glantz S. A., Chaffee B. W. Association of Noncigarette Tobacco Product Use With Future Cigarette Smoking Among Youth in the Population Assessment of Tobacco and Health (PATH) Study, 2013-2015. *JAMA Pediatrics*. 2018;172(2):181-187.

Watkins et al. used data from the national Population Assessment of Tobacco and Health (PATH) survey to determine whether adolescents use of electronic cigarettes, hookah, noncigarette combustible tobacco, or smokeless tobacco led to cigarette smoking initiation. The authors stated that, "in addition to their direct health effects, how these products affect youth cigarette smoking is a major consideration in determining their net influence on public health." PATH is a nationally representative survey of 12 to 17 year olds, and the authors completed a longitudinal evaluation of survey responses for 10,384 youth from 2013 and 2015. At baseline, approximately 9% of youth had never tried a cigarette and had tried at least one non-cigarette tobacco product. They found that cigarette imitation was higher among youth that had used e-cigarettes, hookah, noncigarette combustible tobacco, or smokeless tobacco. Overall, "the odds of past 30-day cigarette use at follow-up were approximately twice as high among baseline ever users of e-cigarettes (odds ratio [OR], 1.87; 95% CI, 1.15-3.05), hookah (OR, 1.92; 95% CI,

1.17-3.17), noncigarette combustible tobacco (OR, 1.78, 95% CI, 1.00-3.19), and smokeless tobacco (OR < 2.07; 95% CI, 1.10-3.87)." The authors found that "ever use of e-cigarettes was associated with 2.53 times greater odds of subsequent cigarette use." Using two or more types of non-cigarette tobacco products was associated with 4 times greater odds of past 30-day cigarette smoking at follow-up (OR, 3.95, 95% CI, 2.65-5.90, P<.001). The authors cite previous research showing that "approximately 90% of adult smokers first tried a cigarette by 18 years of age, and even infrequent smoking in adolescence is associated with established adult smoking."

38. Soneji S., Barrington-Trimis J.L., Wills T.A., et al. Association Between Initial Use of e-Cigarettes and Subsequent Cigarette Smoking Among Adolescents and Young Adults-- A Systematic Review and Meta-analysis. *JAMA Pediatrics*. 2017;171(8):788-797.

Soneji et al. conducted a systematic review and meta-analysis of longitudinal studies to determine whether initial use of e-cigarettes leads to subsequent cigarette smoking among youth and young adults. They included 9 studies in their analysis. Overall, they found that e-cigarette use was strongly and consistently associated with greater risk for cigarette smoking initiation (OR 3.50, 95% CI 2.38-5.16) and past 30-day cigarette smoking (OR 4.28, 95% CI 2.52-7.27) among youth and young adults. In addition, their analysis found that e-cigarette use is an independent risk factor for cigarette smoking, after controlling for multiple additional risk factors.

39. Leventhal Adam M., Strong David R., Kirkpatrick Matthew G., et al. Association of electronic cigarette use with initiation of combustible tobacco product smoking in early adolescence.(Report). 2015;314(7):700.

Leventhal et al. cite evidence that electronic cigarettes are being used among teens who have never used combustible cigarettes. They cite a 2014 estimate that in the United States 43% of 10th graders who reported using e-cigarettes in the previous 30 days reported never having tried combustible cigarettes. Leventhal et al. analyze data from a longitudinal survey of high school students from a convenience sample of 10 public high schools in the Los Angeles, California area. They collected data in three waves: baseline (fall 2013; 9th grade), 6-month follow-up (spring 2014), and 12-month follow-up (fall 2014; 10th grade). The final sample included students who completed all three waves of the survey (n=2,530). They found that students who reported e-cigarette use at baseline were also more likely to report use of combustible tobacco products in the previous 6 months. After adjusting for potential confounding factors, the authors found that baseline e-cigarette use was also associated with a higher likelihood of using combustible tobacco products (cigarettes, cigars, or hookah) at follow-up (averaged across the two follow-up periods OR 2.73 [95% CI 2.00-3.73]). This trend was also true for combustible cigarettes specifically (OR 3.25 [95% CI 2.29-4.62]).

40. Thomas A Wills, Rebecca Knight, James D Sargent, et al. Longitudinal study of e-cigarette use and onset of cigarette smoking among high school students in Hawaii. *Tobacco Control*. 2016.

Wills et al. analyzed 2013 and 2014 longitudinal school-based survey data from Hawaii. The baseline sample included 2,338 9th and 10th graders. Students who were not smokers at baseline but who had used e-cigarettes were significantly more likely to have smoked combustible cigarettes at the one-year follow-up than their non-smoking peers who had never tried e-cigarettes (OR 2.87 [95% CI 2.03-4.05]). Among students who had tried combustible cigarettes

at baseline, using e-cigarettes was not significantly related to changes in their frequency of smoking traditional cigarettes at follow-up.

41. **Protano C., Avino P., Manigrasso M., et al. Environmental Electronic Vape Exposure from Four Different Generations of Electronic Cigarettes: Airborne Particulate Matter Levels. *International Journal of Environmental Research and Public Health*. 2018;15(2172).**

Protano et al. evaluated the levels of airborne particulate matter emitted by four generations of e-cigarette models in use in Italy. They found that all e-cigarette devices emitted particulate matter of a size that can be inhaled into the lungs (including PM10, PM4, PM2.5, and PM1). Newer models emitted greater levels of small particulate matter as a result of increased operating power. Overall, their findings suggest that passive vaping does occur, supporting "the need for legislative interventions to regulate e-cigs use in public places and other enclosed environments, in order to protect the health of any subject who is potentially exposed."

42. **QxQ Analysis: E-Cigarette/Vapor Product Use by Race/Ethnicity, Sexual Orientation, and Gender Identity. Looking Glass Analytics; 2018. <http://www.askhys.net/Analyzer>. Accessed September 2019.**

Washington State Healthy Youth Survey data from 2018 indicate that among 8th grade respondents the highest rate of vaping was reported among Hispanic students (15.4% [95% CI 12.0-18.8%]), followed by American Indian or Alaska Native (AI/AN) students (14.6% [95% CI 9.4-19.8%]) and black students (13.6% [95% CI 8.5-18.7%]). Among 10th grade respondents, AI/AN students (28.0% [95% CI 18.7-37.3%]) and multi-racial students (24.4% [95% CI 20.7-28.1%]) reported higher smoking rates than their peers. The percent of students who had reported using e-cigarette/vapor products at all in the past 30 days was highest among 12 grade respondents. AI/AN students (38.3% [95% CI 24.6-52.0%]) and multi-racial students (35.2% [95% CI 30.8-39.7%]) reported higher rates of using e-cigarettes/vapor products than their peers. Among 12th graders, the lowest rates of e-cigarette/vapor product use were reported by Asian and Black/African American students. These data suggest that in Washington State, AI/AN, and multi-racial, and Hispanic youth have disparately high rates of current e-cigarette/vapor product use. It is important to note that the current race/ethnicity categories aggregate diverse subpopulations into one category—so disparities within these categories may be masked. For example, API subpopulations likely have very different smoking rates but they are aggregated into one category so these differences may be missed. White respondents in 10th and 12th grade also report high e-cigarette/vapor product current use compared to cigarette use. Students from the subsample of schools who participate in the extended form version of the Healthy Youth Survey also answered questions about their sexual orientation. Eighth grade respondents who identified as lesbian, gay, or bisexual were more likely to report using e-cigarettes/vapor products at all in the last 30 days (16.5% [95% CI 10.8-22.2%]) than their peers who identified as straight (10.1% [95% CI 7.9-12.3%]). This disparity also existed among 10th graders (32.1% [95% CI 27.4-36.8%] vs. 20.8% [95% CI 17.7-23.9%]) and 12 graders (35.4% [95% CI 29.9-40.9%] vs. 28.1% [95% CI 24.3-31.9%]). Finally, the Healthy Youth Survey also asks students about their gender identity. Eighth grade and 12th grade data were suppressed due to fewer than 5 responses in at least one category. Among 10th grade respondents who identified as transgender were more likely to report using e-cigarettes/vapor products at all in the last 30 days (44.7% [95% CI 26.6-62.8%]) than their peers who identified as cisgender female (22.4% [95%

CI 19.3-25.5%]) or cisgender male (20.8% [95% CI 17.5-24.1%]). Disparities also exist for students who report something else fits better (30.0% [95% CI 14.8-45.2%]), questioning/not sure of my gender identity (24.4% [95% CI 12.4-36.4%]), and who selected more than one response (28.0 [95% CI 14.0-42.0%]).

43. Kann L., McManus T., Harris W.A., et al. Youth Risk Behavior Surveillance--United States, 2017. *Morbidity and Mortality Weekly Report, Centers for Disease Control and Prevention*. 2018;67(8).

This MMWR Surveillance Report provides updated findings from the 2016-2017 Youth Risk Behavior Surveillance System (YRBSS) on the leading causes of morbidity and mortality among youth, including unintentional injuries and violence; tobacco use; alcohol and drug use; sexual behaviors; dietary behaviors; and physical inactivity. It presents data on health behaviors and health disparities by sex, race/ethnicity, grade in school, and sexual orientation. This is the first YRBSS survey that reports on questions added in 2015 related to sexual orientation. Washington State did not participate in the 2016-2017 YRBSS. Specific to tobacco use, this version of YRBSS either changed the wording of the question or response or asked a question for the first time related to the following measures: "having first tried cigarette smoking before age 13 years; having usually gotten their own electronic vapor products by buying them in a store; current, current frequent, and current daily smokeless tobacco uses; current cigarette, cigar, or smokeless tobacco use; current cigarette, cigar, smokeless tobacco, or electronic vapor produce use; having tried to quit using all tobacco products." From 1991 to 2017, the prevalence of ever trying cigarette smoking significantly decreased from 70.1% to 28.9% nationally. Male, white, and gay, lesbian, and bisexual students were more likely to have ever tried cigarette smoking compared to other students. In addition, this YRBSS asked for the first time about cigarette smoking before 13 years of age, and results indicated that 9.5% of students had tried cigarette smoking before 13 years of age. From 1991 to 2017, the prevalence of current cigarette use (smoked a cigarette at least once in the past 30 days) also significantly decreased from 27.5% to 8.8% nationally. Among students that currently used cigarettes, the prevalence was higher for males (9.8%) than females (7.8%), and whites (11.1%) compared to Hispanic (7.0%) or black (4.4%) students. Current cigarette use was almost twice as high among gay, lesbian, and bisexual students (16.2%) compared to heterosexual students (8.1%). Nationally, 2.6% of students had smoked cigarettes on 20 or more days in the past 30 days, and 2.0% of students had smoked cigarettes on all 30 days. Frequent cigarette use was higher among whites and gay, lesbian, and bisexual students. Nationally, 42.4% of students had every used an electronic vapor product (e.g. e-cigarettes, e-cigars, e-pipes, vape pipes, vaping pens, e-hookahs, hookah pens), and 13.2% of students currently used e-cigarettes (used an electronic vapor product at least once in the past 30 days). Among students that currently used e-cigarettes, the prevalence was higher for males (15.9%) than females (11.8%); whites (15.6%) compared to Hispanic (11.4%) or black (8.5%) students; and gay, lesbian, and bisexual students (17.5% compared to 13.2% of heterosexual students). Nationally, 3.3% of students had used an electronic vapor product on 20 or more days in the past 30 days, and 2.4% of students had used an electronic vapor product on all 30 days. Frequent vapor product use was higher among male, white, and gay, lesbian, and bisexual students. Among students that currently used electronic vapor products, 13.6% had gotten their own electronic vapor products by buying them in a store. Nationally, 5.5% of students currently used a smokeless tobacco product (e.g. chewing tobacco, snuff, dip, snus, or a dissolvable tobacco product). Approximately 24% of students had used any tobacco product during the past

12 months. Of these students, 41.4% had tried to quit and females, whites and Hispanics, and gay, lesbian, and bisexual students were more likely to have tried to quit. Overall, males were more likely to have engaged in tobacco use risk behaviors than females. White students were more likely to have engaged in tobacco use risk behaviors than Hispanic or black students. Gay, lesbian, and bisexual students were more likely to have engaged in tobacco use risk behaviors than heterosexual students, and the prevalence for current, current frequent, and current daily cigarette use was twofold or greater for gay, lesbian, and bisexual students compared to heterosexual students. The prevalence for current frequent and current daily cigarette use, and current frequent and current daily cigar use was twofold or greater for students who had sexual contact with only the same sex or with both sexes compared to students who had sexual contact with only the opposite sex.

44. Healthy Youth Survey Fact Sheets: Tobacco Use and Tobacco & Vapor Product Use. Healthy Youth Survey Fact Sheets. Looking Glass Analytics; 2018.

Analysts reviewed Washington State Healthy Youth Survey Fact Sheets for Tobacco and Tobacco & Vapor Product Use for grade levels 8, 10, and 12. These fact sheets provide current use trends for tobacco products (vapor products, cigarettes, and smokeless tobacco), statewide current use by race/ethnicity, single and dual use (cigarettes and vapor products), reported substance "vaped", and source. The most commonly reported substances "vaped" among current users across grade levels contain nicotine or flavor only (no nicotine or THC). The most commonly reported substance vaped among 8th graders is flavor only (44%), followed by nicotine in it (39%), THC (marijuana) in it (17%), and substance unknown (14%). Among 10th and 12th graders, the most commonly reported substance vaped contains nicotine (56% and 62%, respectively), followed by flavor only (33% and 26%), THC in it (21% and 24%), and substance unknown (10% and 8%).

45. Simon Patricia , Camenga Deepa R. , Morean Meghan E. , et al. Socioeconomic status and adolescent e-cigarette use: The mediating role of e-cigarette advertisement exposure. *Preventive Medicine*. 2018;112(2018):193-198.

Simon et al. examined "exposure to e-cigarette advertisements as a mediator of the relationship between [socioeconomic status (SES)] and adolescent e-cigarette use." While low SES is associated with "greater exposure to tobacco cigarette advertising and cigarette use," associations among SES, e-cigarette advertising, and e-cigarette use are not yet well understood. Authors used anonymous survey data collected from adolescents (N = 3,473; 51% Female) attending 8 high schools in Connecticut in Spring 2015. "Mediation analysis was used to examine whether the total number of sources of recent e-cigarette advertising exposure (e.g., TV, radio, billboards, magazines, local stores [gas stations, convenience stores], vape shops, mall kiosks, tobacco shops, social media) mediated the association between SES (measured by the Family Affluence Scale) and past-month frequency of e-cigarette use." Researchers "clustered for school and controlled for other tobacco product use, age, sex, race/ethnicity and perceived social norms for e-cigarette use in the model." The sample had recently seen e-cigarette advertisements via 2.1 (SD = 2.8) advertising channels. "Mediation was supported (indirect effect: $\beta = 0.01$, SE = 0.00, 95% CI [0.001, 0.010], $p = 0.02$), such that higher SES was associated with greater recent advertising exposure, which, in turn, was associated with greater frequency of e-cigarette use." Results suggest that "regulations to reduce youth exposure to e-cigarette advertisement may be especially relevant to higher SES youth." Authors recommend future research "examine these

associations longitudinally and evaluate which types of advertisements target different SES groups."

46. **Zhu Shu-Hong, Zhuang Yue-Lin, Braden Katherine, et al. Results of the Statewide 2017-18 California Student Tobacco Survey. San Diego, California: Center for Research and Intervention in Tobacco Control (CRITC); 2019.**

This report summarized the main results from the 2017-18 California Student Tobacco Survey (CSTS), which was administered to 8th, 10th, and 12th grade students from September 2017 to June 2018. Random selection of California middle and high schools resulted in 333 schools and 151,404 students participating in the survey. Results show that students in San Mateo and San Francisco Counties reported current e-cigarette use at nearly double (20.8%) the use statewide (10.9%).

47. **Defense Department of. 2015 Health Related Behavior Survey for Active Duty Service Members. 2015.**

The Health Related Behavior Survey for Active Duty Service Members is a Department of Defense survey used to track health indicators for all branches of active-duty military personnel. Survey data from 2015 indicated that e-cigarette use has been increasing among military personnel. In 2015, 35.7% of military personnel reported ever trying e-cigarettes compared to 12.6% of the general population and 11.1% reported being daily e-cigarette users compared to 3.7% of the general population. The survey also found that 80.7% of military personnel reported buying cigarettes on a military base. Use also varied by branch and rank. All forms of tobacco use, including e-cigarette use, were highest among the Marine Corps (16.1%). E-cigarette use was also higher among lower ranking personnel. For example, 20% of junior enlisted personnel currently used e-cigarettes compared to 10.8% of mid-level enlisted personnel, 6.1% of senior enlisted personnel, 3.4% of warrant officers, 2.2% of junior officers, and 0.9 % of mid-grade or senior officers. Active-duty military members "aged 17-24 were almost ten times more likely to be a current e-cigarette smoker than service members aged 45 or older." By age, 22.8% of personnel aged 17-24 currently used e-cigarettes, 10.8% of personnel aged 25-34, 5.4% of personnel aged 35-44, and 2.5% of personnel older than age 45. Military personnel identifying as Hispanic and personnel having high school education or less also used e-cigarettes at a higher rate.

48. **Barrington-Trimis Jessica L. , Kong Grace , Leventhal Adam M. , et al. E-cigarette Use and Subsequent Smoking Frequency Among Adolescents. *Pediatrics*. 2018;142(6).**

E-cigarette use is associated with cigarette initiation. Barrington-Trimis et al. pooled data from 3 prospective cohort studies in California and Connecticut (baseline: 2013-2014; follow-up: 2014-2016; N = 6,258) to assess whether e-cigarette use is associated with more frequent cigarette use after initiation or whether adolescent cigarette or dual product users transition to e-cigarette use or nonuse. Authors found that fewer never e-cigarette users (at baseline) began smoking (7%) compared to those who had used e-cigarettes at baseline (21% reported smoking cigarettes at follow-up). "Baseline exclusive e-cigarette users had higher odds of reporting exclusive e-cigarette use at follow-up (OR = 7.28; 95% CI: 4.86–10.9), exclusive cigarette use at follow-up (OR = 3.84; 95% CI: 1.80– 8.19), or dual product use at follow-up (OR = 8.86; 95% CI: 5.08– 15.4)." Once youth began smoking cigarettes (either never e-cigarette users or e-cigarette users at baseline) the amount that they smoked was similar. Researchers found, "Among baseline never

smokers, e-cigarette users had greater odds of subsequent experimental (odds ratio [OR] = 4.58; 95% confidence interval [CI]: 3.56–5.88), infrequent (OR = 4.27; 95% CI: 2.75–6.62) or frequent (OR = 3.51; 95% CI: 1.97–6.24) cigarette use; the 3 OR estimates were not significantly different." Whereas, "[b]aseline past-30-day exclusive cigarette use was associated with higher odds at follow-up of exclusive cigarette or dual product use than of exclusive e-cigarette use."

49. Mantey D. S., Omega-Njemnobi O., Montgomery L. Flavored tobacco use is associated with dual and poly tobacco use among adolescents. *Addict Behav.* 2019;93:269-273.

Mantey et al. examined the relationships between flavored tobacco use and single, dual, and poly tobacco product use, among adolescents. Researchers obtained cross-sectional data from the 2017 National Youth Tobacco Survey (NYTS). Participating adolescents (N=2,042) were past 30-day tobacco users. Tobacco use was assessed for 9 products (cigarettes, e-cigarettes, hookah, cigar products (i.e., cigars, little cigars, cigarillos), smokeless tobacco, snus, pip tobacco, bidis, and dissolvable tobacco. "Multivariable multinomial logistic regression models were used to assess the relationship between flavored tobacco use and past 30-day single, dual, and poly (three or more) tobacco product use." Data were weighted to be representative of U.S. middle and high school students, adjusting for nonresponse and probability of selection. Researchers conducted two analyses using different categories as referent groups "to allow for a comprehensive examination of the relationship between all groups. Covariates included sex, grade level, race/ethnicity and exposure to tobacco marketing." Data showed flavored tobacco use prevalence differed significantly by race/ethnicity ($p < 0.001$); non-Hispanic whites had the greatest prevalence (74.7%) followed by Hispanic/Latinos (66.5%). Additionally, "[s]ingle, dual, and poly tobacco use prevalence differed significantly by race ($p = .035$). Single product use prevalence was greatest among non-Hispanic blacks (66.5%). Dual product use was greatest among non-Hispanic whites (21.3%). Poly tobacco use was greatest among Hispanic/ Latinians (28.9%)." Approximately half of all participating adolescent tobacco users (45.7%) reported use of more than one product, and most adolescent tobacco users reported using flavors (69.4%). Specifically, analysis of 2017 National Youth Tobacco Survey results found that among dual and poly tobacco users, the most commonly used flavored tobacco products were e-cigarettes (34.3% and 44.6%, respectively), cigars (23.8% and 41.5%, respectively), and convention cigarettes (21.9% and 33.9%, respectively). After controlling for covariates, "[f]lavored tobacco use was significantly correlated with a greater risk of dual (RRR: 2.09) and poly (RRR: 5.54) tobacco use, relative to single product use." Moreover, "flavored tobacco use was significantly correlated with a greater risk of poly (RRR: 2.66) tobacco use, relative to dual tobacco use, controlling for covariates." Overall, authors noted a positive relationship for flavored tobacco use and multiple tobacco product use. Authors conclude, "[f]indings suggest the need to consider stronger regulations of flavored tobacco products [...] [and] the need to emphasize flavored tobacco use in prevention and education programs."

50. Management Washington State Office of Financial. Multiple Agency Fiscal Note Summary: HB 1550 (Nicotine addiction). 2021.

The Washington State Office of Financial Management completed a Fiscal Note for HB 1550 (revised 3/23/2021).

51. **Information for tribal members/citizens. 2021; Available at: <https://dor.wa.gov/get-form-or-publication/publications-subject/tax-topics/information-tribal-memberscitizens>. Accessed 2/25/2021.**

The Washington State Department of Revenue provides information about taxes for tribal members/citizens. They state that, “tribal members/citizens do not pay state taxes for their transactions that occur in their Indian Country.”

52. **Washington State House of Representatives Office of Program Research. Bill Analysis: HB 1550, Concerning methods to prevent nicotine addiction. 2021.**

The Office of Program Research published a Bill Report for HB 1550.

53. **Wang T.W., Gentzke A., Sharapova S., et al. Tobacco Product Use Among Middle and High School Students--United States, 2011-2017. *Morbidity and Mortality Weekly Report, Centers for Disease Control and Prevention*. 2018;67(22):629-633.**

Centers for Disease Control and Prevention and the Food and Drug Administration evaluated data from the National Youth Tobacco Surveys from 2011 to 2017. They estimated nationwide current use of tobacco products for students in middle and high school. Overall, they found that tobacco use decreased from 24.2% of high school students (grades 9-12) in 2011 to 19.6% of high school students in 2017, and from 7.5% of middle school students (grades 6-8) in 2011 to 5.6% of middle school students in 2017. E-cigarettes were the most commonly used tobacco product across all grades. Although use of tobacco products decreased overall, e-cigarette use increased from 1.5% of high school students in 2011 to 11.7% of high school students in 2017. E-cigarette and hookah use also increased from 2011 to 2017 for middle school students. Currently, "in 2017, approximately one in five high school students (2.95 million) and one in 18 middle school students (0.67 million) currently used a tobacco product." The authors note that, "several factors continue to promote and influence tobacco product use among youths, including exposure to tobacco product advertising and imagery through various media, as well as the availability of flavored tobacco products."

54. **Gentzke A., Wang T.W., Jamal A., et al. Tobacco Product Use Among Middle and High School Students --United States, 2020. *Morbidity and Mortality Weekly Report*. 2020;69(50):1882-1888.**

This Morbidity and Mortality Weekly Report (MMWR) from the Centers for Disease Control and Prevention (CDC) summarized updated data on tobacco use among middle and high school students based on the 2019 and 2020 National Youth Tobacco Surveys. In 2020, 16.2% of all students grades 6 through 12 reported tobacco use, including 6.7% of students in grades 6 through 8 and 23.6% of students in grades 9 through 12. Use of any tobacco product significantly declined from 2019 to 2020. E-cigarette use also decreased from 2019 to 2020. E-cigarette use decreased from 27.5% to 19.6% of high school students and from 10.5% to 4.7% of middle school students. However, e-cigarettes remained the most commonly used product among both middle and high school students. There was no change in cigarette smoking rates over the same time period. CDC noted that these declines may be attributable to a number of factors, including: 1) In 2019, the federal minimum age of sale for all tobacco products was raised from 18 to 21; 2) In 2020, the Food and Drug Administration prioritized enforcement of flavored e-cigarette products that appealed to youth; 3) State action (including action in Washington State) to restrict

access to flavored products; 4) Response to EVALI; and 5) FDA's public education campaign to reduce youth e-cigarette and tobacco use.

55. Cullen K.A., Ambrose B.K., Gentzke A.S., et al. Notes From The Field: Use of Electronic Cigarettes and Any Tobacco Product among Middle and High School Students--United States, 2011-2018. *Morbidity and Mortality Weekly Report, Centers for Disease Control and Prevention*. 2018;67(45).

E-cigarettes entered the U.S. market in 2007, and were the most commonly used tobacco product among youth by 2014. This Morbidity and Mortality Weekly Report update provides a summary of adolescent e-cigarette use in the U.S. from 2011 to 2018. Using data from the National Youth Tobacco Survey, this update shows that e-cigarette use among high school and middle school students statistically significantly increased between 2011 and 2018. For high school students, 1.5% of students reported using e-cigarettes in 2011 and 20.8% reported using e-cigarettes in 2018 ($p < 0.001$). For middle school students, 0.6% reported using e-cigarettes in 2011 and 4.9% reported using e-cigarettes in 2018 ($p < 0.001$). Both groups experienced large increases between 2017 and 2018, with high school use increasing by 78% (11.7% to 20.8% of students, $p < 0.001$) and middle school use increasing by 48% (3.3% to 4.9% of students, $p = 0.001$). The authors attribute the increase in e-cigarette use between 2017 and 2018 to "recent popularity of e-cigarettes shaped like a USB flash drive, such as JUUL."

56. FDA News Release -- FDA finalizes enforcement policy on unauthorized flavored cartridge-based e-cigarettes that appeal to children, including fruit and mint [press release]. Silver Springs, Maryland: U.S. Food & Drug Administration, 2 January 2020 2020.

This FDA News Release announces that the FDA finalized its enforcement policy on unauthorized flavored cartridge-based e-cigarettes that appeal to children, including fruit and mint. "Companies that do not cease manufacture, distribution and sale of unauthorized flavored cartridge-based e-cigarettes (other than tobacco or menthol) within 30 days risk FDA enforcement actions." Health & Human Services (HHS) Secretary Alex Azar states, "HHS is taking a comprehensive, aggressive approach to enforcing the law passed by Congress, under which no e-cigarettes are currently on the market legally." According to the announcement, "For purposes of this policy, a cartridge or pod is any small, enclosed unit (sealed or unsealed) designed to fit within or operate as part of an ENDS product." Data show that cartridge-based ENDS products are most commonly used among youth. "By not prioritizing enforcement against other flavored ENDS products in the same way as flavored cartridge-based ENDS products, the FDA has attempted to balance the public health concerns related to youth use of ENDS products with considerations regarding addicted adult cigarette smokers who may try to use ENDS products to transition away from combustible tobacco products." In addition, "For all other products (cartridge-based or otherwise), including menthol-, tobacco-, and non-flavored ENDS products, the FDA will also prioritize enforcement where the manufacturer fails to take adequate measures to prevent youth access." The statement highlights, "the FDA's enforcement priorities are not a "ban" on flavored or cartridge-based ENDS [...] Manufacturers that wish to market any ENDS product – including flavored e-cigarettes or e-liquids – are required by law to submit an application to the FDA that demonstrates that the product meets the applicable standard in the law." Furthermore, "If a company can demonstrate to the FDA that a specific product meets the applicable standard set forth by Congress, including considering how the marketing of the

product may affect youth initiation and use, then the FDA could authorize that product for sale." Finally, "The guidance also states that, after May 12, 2020, the FDA intends to also prioritize enforcement against any ENDS products that continue to be sold and for which the manufacturers have not submitted a premarket application."

57. General Office of the Surgeon. Reducing Tobacco Use a Report of the Surgeon General. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office of Smoking and Health; 2000.

This report was prepared by the Centers for Disease Control and Prevention's National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health. It focused on examining past and current efforts to reduce the use of tobacco assessing methods and tools available. "The research findings reviewed indicate that many strategies and approaches have been shown to be effective in preventing tobacco use among young people and in helping tobacco users end their addiction." Chapter 6 focused on economic approaches to reduce tobacco use.

58. Pepper J. K., Coats E. M., Nonnemaker J. M., et al. How Do Adolescents Get Their E-Cigarettes and Other Electronic Vaping Devices? *American Journal of Health Promotion*. 2018;890117118790366.

Pepper et al. conducted an online survey of 1,729 adolescents aged 15-17 who reported vaping in the past 30 days (using an e-cigarette or similar device) to determine how youth obtain or access vaping devices. Adolescent use of e-cigarettes increased significantly between 2011 and 2015, and in 2016 11% of U.S. 10th graders and 12% of U.S. 12 graders reported vaping. Minimum purchase age for e-cigarettes was established nationally as 18 years in 2016. While prior studies have found that social sources are the main way adolescents access cigarettes, little is known about how adolescents access e-cigarettes and other devices. Approximately half of respondents reported smoking cigarettes in the past 30 days, and one-third of respondents reported using other tobacco products in the past 30 days. They found that 78.2% of adolescents surveyed owned their own vaping device, with 32.2% purchasing their device online and 22.3% purchasing it in a vapor shop or lounge. Sources varied significantly by sex, race/ethnicity, and poly tobacco use. In addition, 72.8% reporting using someone else's vaping device in the past 30 days, with 80.5% who borrowed stating that they borrowed from a friend. Adolescents were more likely to borrow a vaping device if they vaped more often, did not own their own, vaped in social situations, or had been refused purchase. The authors suggested that, "social sources might be even more important for vaping than for smoking cigarettes; cigarette smokers likely get cigarettes from other people only when they do not possess their own, but vapers use others' devices even when they have their own."

59. Meyers M. J., Delucchi K., Halpern-Felsher B. Access to Tobacco Among California High School Students: The Role of Family Members, Peers, and Retail Venues. *Journal of Adolescent Health*. 2017;61(3):385-388.

Meyers et al. surveyed 772 adolescents in California to determine how they obtain cigarettes, e-cigarettes, and hookah. They recruited 9th and 12th grade students from 8 high schools in California to participate in a longitudinal study related to tobacco access, perceptions, social norms, marketing, and use. In general, 32.7% of students reported using hookah, 28.7% reported

using e-cigarettes, and 19.2% reported using cigarettes. Approximately 55% of respondents reporting getting their tobacco products from peers, and "adolescents [were] significantly more likely to obtain hookah, e-cigarettes, and cigarettes from a friend than any of the other sources addressed." Of students who purchased tobacco products, students were significantly more likely to purchase e-cigarettes or hookah from a smoke shop than any other retailer. The authors found that, "9.3% of participants under the age of 18 reported purchasing tobacco products themselves...thus, despite legislation banning the sale to minors, [adolescents and young adults] continue to directly purchase tobacco products at alarming rates." However, this survey was completed before California enacted their Tobacco 21 law.

60. Boom A. Raising Cigarette Taxes Reduces Smoking, Especially Among Young Kinds. Washington, DC: Campaign for Tobacco-Free Kids; 2021.

This document from the Campaign for Tobacco-Free Kids cites evidence from tobacco company memos, economic research, and national and international organizations that raising cigarette taxes reduces smoking, particularly among youth.

61. Behar R. Z., Wang Y., Talbot P. Comparing the cytotoxicity of electronic cigarette fluids, aerosols and solvents. *Tob Control*. 2017;27(3):325-333.

Behar et al. evaluated the cytotoxicity of e-cigarette refill fluids and corresponding aerosol as well as propylene glycol and glycerin (common solvents) using three different types of human cells. Overall, they found that various brands and flavors of e-cigarette fluids are cytotoxic. The authors conducted a previous study evaluating the cytotoxicity of chemicals used to flavor e-cigarette refill fluids. That study found that, "cinnamon-flavoured products were particularly cytotoxic, and cinnamaldehyde was identified as the most potent additive in these fluids. We also reported that cinnamaldehyde is widely used in refill fluids, including popular fruity and sweet flavours, and that it produces adverse effects on cells at doses that do not cause cell death." Other studies have also shown that cherry-flavored products (benzaldehyde) and chocolate-flavored products (2,5-dimethylpyrazine) are potentially harmful. They also cite other research showing that e-cigarette use has numerous health effects, including respiratory, cardiac, and digestive system effects, unintentional and intentional poisonings, and injuries due to explosion. They also stated that in vitro studies have found that e-cigarettes can cause cell inflammation, apoptosis, and DNA damage. In this study, the authors evaluated 36 e-cigarette refill fluids representing a range of brands and flavors. Fluids testing included tobacco-flavored, propylene glycol, vegetable glycerin, and pure nicotine liquid. In addition, the authors produced corresponding aerosols using a smoking machine. The fluids and aerosols were tested using three types of cells. Human pulmonary fibroblasts are a cell type that is first exposed to inhaled aerosol and are involved in the development of lung diseases. Lung epithelial cells are cells commonly used in toxicological inhalation testing. Pluripotent human embryonic stem cells were also used to approximate potential impacts to human embryos. All of the tests included dose-response experiments. The authors found that 34 of the 35 products were significantly more toxic at high concentrations than at low concentrations. Creamy/buttery, mint/menthol, tobacco, and fruit flavoring categories were the most potent. The six most potent flavorings were in the creamy/buttery category and included flavorings like Swiss Dark, Butterfinger, Caramel, and Butterscotch. In general, the embryonic stem cells were more sensitive to e-cigarette fluids and aerosols than adult lung cells. Overall, 54% (19 products) were cytotoxic in both the fluid and aerosol form; 23% (8 products) were cytotoxic in the aerosol form but not the fluid form; and 3% (1 product) were cytotoxic in

the fluid form but not the aerosol form. Twenty percent (7 products) were found to be non-cytotoxic in both the fluid and aerosol form. In addition, refills containing glycerin were the most cytotoxic, and 91% of glycerin-based refill fluids were cytotoxic when aerosolized. Vegetable glycerin alone was also cytotoxic when aerosolized, and was found to be more cytotoxic than propylene glycol alone. The authors noted that many flavoring liquids may be approved for ingestion, but have not been tested for safety of inhalation.

62. Center Washington Poison. Washington Poison Center 2018 Annual Data Report: Nicotine. 2018.

In 2018, the Washington Poison Center addressed 483 cases of nicotine exposure, including 353 cases of nicotine exposure among 0-5 year olds. 87% of exposures were due to ingestion, and included gastrointestinal, neurological, respiratory, ocular, cardiovascular, and dermal symptoms. Washington Poison Center also addressed 136 cases specific to e-cigarettes, including 77 cases among 0-5 year olds, 2 cases among 6-12 year olds, 23 cases among 13-20 year olds, 26 cases among 21-59 year olds, and 1 case among 60 years and older.

63. IOM. Public health implications of raising the minimum age of legal access to tobacco products. Washington D.C.: The National Academies Press; 2015.

The Tobacco Control Act of 2009 directed the Food and Drug Administration (FDA) to convene a panel of experts to conduct a study on the health impacts of raising the minimum purchase age for tobacco products and submit a report to Congress. The FDA contracted with the Institute of Medicine (IOM) to convene a committee to examine the existing literature and use modeling to predict the likely impacts of increasing the minimum purchase age to 21 or 25 years of age. The committee concluded in their report that increasing the minimum purchase and possession age for tobacco products would likely prevent or delay initiation of tobacco use by adolescents and young adults and therefore also lead to a “substantial reduction in smoking-related mortality.” The authors also concluded that while (for a purchase age of 21) 18 to 20 year olds would be affected, the largest reduction in tobacco initiation would likely be among 15 to 17 year olds. They note that increasing the purchase age to 19 would likely have a modest impact on decreasing tobacco access to minors compared to increasing the age to 21. The authors cite evidence that younger age of smoking initiation is associated with heavier smoking later in life, a higher likelihood of continuing to smoke through the lifespan, and increased risk of adverse health outcomes. The report also summarizes the literature on the effect of tobacco purchase, use, and possession (PUP) laws. A 2008 study conducted in California by Rogers et al. found that in the previous 12 months, across all 249 enforcement agencies statewide, an average of 24.1 citations were issued per agency. A study by Gottlieb et al. also found that African-American and Hispanic students were significantly more likely than their White counterparts to receive a PUP citation. Jason et al. (2007b) found that youth who were fined for PUP violations were more likely than youth in a tobacco prevention education program to reduce or quit tobacco use. However Gottlieb et al. (2004) found that receiving a PUP citation was only associated with reduced smoking intention in some of the sample schools. The committee conducted modeling (informed by the existing scientific literature) and estimated that raising the tobacco purchase age to 21 would lead to the following reductions in tobacco initiation: 15% (range: 12.5-18%) reduction for those under 15 years of age, 25% (range: 20.8-30%) reduction for those 15-17 years, 15% (range 12.5-18%) reduction for those 18-20 years. Their modeling predicts that with an age 21 minimum, by 2040-2059 there would be 0.2-0.8% reduction in deaths (8.2-9.9% by

2080-2099); 0.5% reduction in years of life lost (9.3% by 2080-2099); 0.3% reduction in lung cancer deaths (10.5% by 2080-2099); 12.2% reduction in low birth weight cases; 13% reduction in pre-term birth cases; and 18.5% reduction in sudden infant death syndrome (SIDS) cases.

64. Caporale A., Langham M.C., Guo W., et al. Acute Effects of Electronic Cigarette Aerosol Inhalation on Vascular Function Detected at Quantitative MRI. *Radiology*. 2019;00:1-10.

Caporale et al. provided background research about each component of e-cigarettes, including the solvents, metals generated by the heating elements, and flavorants. They noted that, “the basic constituents of e-liquids, primarily propylene glycol and glycerol, can form irritant acetals even at room temperature and carcinogens at typical working device temperatures.” The heating elements produce fine and ultrafine metal particles that have been shown to cause nose, throat, and respiratory irritation, lung inflammation, and nervous system damage. Caporale et al. conducted a prospective study with 31 healthy, adult non-smokers (aged 18 to 35) to determine the impact of smoking nicotine-free e-cigarettes. Participants had healthy BMI ranges, no history of smoking, and no obvious cardiovascular or neurovascular disease. Participants underwent an MRI before and after smoking 16 inhalations of nicotine-free e-cigarettes containing propylene glycol, glycerol, and flavor. They measured, “peripheral hyperemia in response to cuff-induced ischemia, cerebrovascular reactivity in response to breath hold, aortic pulse wave velocity, and an indicator of aortic stiffness.” Overall, after vaping, they found, “reductions after vaping in luminal flow-mediated dilation (-3.2 of 9.4; -34%; P<.001), reactive hyperemia peak velocity (-9.9 of 56.6 cm/sec; -18%; P<.001), and acceleration (-3.9 of 15.1 cm/sec²; -26%; P<.001) as representative of macrovascular alterations; a reduction in precuff occlusion Svo₂ (-13 OF 65 %hBO₂; -20%, P<0.001), which indicated transient microvascular impairment; a marginal increase in aortic pulse wave velocity (0.19 of 6.05 m/sec/ 3%; P=.05), which suggested aortic stiffening; and no statistically significant alterations in cerebrovascular reactivity measured by breath-hold index.” The authors noted that they did not determine whether the effects were due to the solvent, flavor, or thermal degradation.

65. Erythropel H.C., Davis L.M., de Winter T.M., et al. Flavorant-Solvent Reaction Products and Menthol in JUUL E-Cigarettes and Aerosol. *American Journal of Preventive Medicine*. 2019;57(3):425-427.

Erythropel et al. examined the composition of JUUL aerosol. They evaluated 8 flavors of JUUL brand e-cigarettes to evaluate the reaction between vanillin flavoring and propylene glycol, glycerol, menthol, and nicotine benzoate to understand how common JUUL components may interact. JUUL products contain higher concentrations of nicotine than other e-cigarette brands (5% versus 0.3%-2.4%) because they use nicotine benzoate salt that “is perceived as more satisfactory and less harsh” than other products. The authors analyzed e-liquids and used a vaping machine to capture aerosol for analysis. They found that JUUL aerosols include quantities of nicotine similar to cigarettes and levels of acetals known to cause irritation and contribute to inflammation. They explained that, “the average vanillin puff concentration was 101 mg/m³. In comparison, chronic inhalational exposure to vanillin in occupational environments is limited to 10 mg/m³, raising the question of what long-term effects regular inhalation of vanillin at such doses and frequency (200 puffs/pod) might have.” They also found levels of menthol in JUUL products (some of which are not labeled as containing menthol) at levels known to increase nicotine intake.

66. Gerloff J., Sundar I. K., Freter R., et al. Inflammatory Response and Barrier Dysfunction by Different e-Cigarette Flavoring Chemicals Identified by Gas Chromatography-Mass Spectrometry in e-Liquids and e-Vapors on Human Lung Epithelial Cells and Fibroblasts. *Appl In Vitro Toxicol.* 2017;3(1):28-40.

There are over 8,000 flavors of e-cigarettes on the market. Gerloff et al. looked at the impact of e-cigarette flavoring chemicals on lung function. Specifically, they looked at impact of various chemicals on the release of proinflammatory cytokine (interleukin-8) in human lung epithelial cells and human lung fibroblasts in vitro, and on barrier dysfunction in human bronchial epithelial cells. They looked at the impact of various e-liquids at three different concentrations to evaluate dose-response impacts after 24 hours of exposure. The authors stated that, “flavored e-cigs are a public health concern not just because they attract youth for experimentation (gateway for initiating tobacco products) but also due to the presence of chemicals that serve as flavorings that may lead to their own health hazards. Flavoring chemicals contain harmful aerosol constituents, such as maltol, vanillin, acetoin, and diacetyl apart from nicotine, vegetable glycerin, and propylene glycol/glycerol.” In addition, “recent studies have shown that cytotoxic effects posed by e-liquids are mainly due to increasing concentrations of the flavoring agents.” The authors noted that there is a lack of data about potential short and long-term health impacts and toxicity from inhaling flavored chemicals. This study found that acetoin, diacetyl, maltol, and ortho-vanillin significantly induced the release of interleukin-8 in human bronchial epithelial cells. Acetoin, pentanedione, maltol, and ortho-vanillin also induced release of interleukin-8 among human primary lung fibroblast cells. None of the flavorings produced a significant proinflammatory response in lung epithelial cells. E-cigarette flavoring chemicals had a dose-dependent impact on lung epithelial cells and fibroblasts. The authors also found that flavoring chemicals impact barrier dysfunction in human bronchial epithelial cells, which can increase access of pollutants, bacteria, and viruses into the lungs. They authors stated, “previously, it has been shown that soluble components of e-cig, including nicotine exposure, caused a dose-dependent loss of lung endothelial barrier function associated with oxidative stress and inflammatory response. Our data show that nicotine and e-cig flavoring agents...differentially affect epithelial barrier function time dependently. This suggests that both nicotine and flavoring chemicals in e-cigs are equally responsible for compromising epithelial integrity/[tight junctions], which allows particles to cross the epithelial barrier.” The authors noted that “food flavoring chemicals approved and evaluated as safe by FEMA for ingestion are now widely being used in [electronic nicotine delivery systems] without knowing their safety and inhalation toxicity.” This study confirmed that inhaling diacetyl can cause damage to lung cells. They also cited a previous study that found that cytotoxicity was correlated with the total number and concentration of chemicals present in flavored e-cigarettes. Another study found that 30 puffs from cherry-flavored e-cigarettes contained higher levels of benzaldehyde than combustible cigarettes. The authors concluded that, “our finds suggest that flavoring chemicals are present in e-liquid/e-cigar aerosols, which are proinflammatory and long-term exposure to flavoring chemicals may lead to lung injurious responses.”

67. Kosmider L., Sobczak A., Prokopowicz A., et al. Cherry-flavoured electronic cigarettes expose users to the inhalation irritant, benzaldehyde. *Thorax.* 2016;71(4):376-377.

Kosmider et al. tested 145 e-cigarette products for the presence of benzaldehyde, a common ingredient in fruit flavored e-cigarettes and a chemical known to cause respiratory irritation in animal and occupational studies. They tested e-liquid aerosols for the presence of benzaldehyde and compared levels from 30 puffs with levels from one combustible cigarette as well as with levels predicted to be inhaled occupationally during an 8 hour work shift. The authors detected benzaldehyde in 108 out of 145 e-cigarette products, most commonly in cherry-flavored products. At levels found, 30 puffs of e-cigarettes flavored with benzaldehyde were higher than doses inhaled from conventional cigarettes and more than 1000 times lower than occupational exposures. The authors noted, "although many flavourings used in e-cigarettes are generally recognized as safe when used in food products, concerns have been raised about the potential inhalation toxicity of these chemicals." There is a lack of data about the long-term health impacts of inhaling chemicals used in e-cigarette flavorings.

68. Tierney P. A., Karpinski C. D., Brown J. E., et al. Flavour chemicals in electronic cigarette fluids. *Tobacco Control*. 2016;25(e1):e10-15.

Tierney et al. measured the flavor chemical components of 30 e-cigarette fluids from two brands: BLU and NJOY. The authors noted that, "adoption of e-cigarettes has far out-paced our understanding of their implications for health, including the initial composition of the e-cigarette fluids as well as presence of harmful by-products formed during 'vaping.'" Flavor compounds are not typically listed on e-cigarette packaging. However, flavoring has been a focus of e-cigarette marketing strategies despite the fact that flavored cigarettes were banned in 2009 based on evidence that flavors attract youth. The authors also quote the Flavor Extracts Manufacturers Association that, "the Flavor Extracts Manufacturers Association Expert Panel does not evaluate flavor ingredients for use in tobacco products including e-cigarettes or other products that are not human food, or products that result in exposures other than ingestion...E-cigarette manufacturers should not represent or suggest that the flavor ingredients used in their products are safe because they have [Flavor Extracts Manufacturers Association 'generally recognized as safe' status for use in food because such statements are false and misleading." Tierney et al. found that flavor chemicals comprised 1-4% of the total fluid, and that six of the 24 isolated chemicals were aldehydes. Aldehydes are "a compound class recognized as 'primary irritants' of mucosal tissue of the respiratory tract." They also found that the majority of tobacco flavored e-cigarettes were found to contain confectionary flavor chemicals, rather than tobacco extracts. Overall, they concluded that, "the concentrations of some flavour chemicals in e-cigarette fluids are sufficiently high for inhalation exposure by vaping to be of toxicological concern." In 13 of the 30 e-liquids tested, flavor chemicals comprised more than 1% by weight. Based on these concentrations, the authors concluded that e-liquid consumption rates may be twice the recommended daily occupational exposure limits by inhalation for benzaldehyde and vanillin flavor chemicals.

69. Omaiye E. E., McWhirter K. J., Luo W., et al. High-Nicotine Electronic Cigarette Products: Toxicity of JUUL Fluids and Aerosols Correlates Strongly with Nicotine and Some Flavor Chemical Concentrations. *Chem Res Toxicol*. 2019;32(6):1058-1069.

Omaiye et al. evaluated the flavor chemical concentrations and nicotine concentrations of the eight pre-filled JUUL e-cigarette pods available on the market (i.e., Cool Mint, Classic Menthol, Mango, Fruit Medley, Cool Cucumber, Crème Brulee, Classic Tobacco, and Virginia Tobacco). The authors tested concentrations in the vape fluid before puffing, after puffing, and in the

corresponding aerosol. Overall, JUUL pods contain solvents, flavor chemicals, and varying concentrations of nicotine. Among the eight flavored pods, the authors identified 59 different flavor chemicals. The concentration of flavor chemicals in JUUL pods ranged from 0.2-15.6 mg/mL, with the highest concentrations of menthol, vanillin, and ethyl maltol. The nicotine concentration of JUUL pods was significantly higher than other e-cigarette products. Most products had nicotine concentrations between 1.6-34.3 mg/mL; JUUL pods had nicotine concentrations between 59.2-66.7 mg/mL. This concentration is also higher than in a pack of cigarettes (40 mg/pack). The transfer of flavor chemicals from the e-liquid to the corresponding aerosol was over 50%, and the transfer of nicotine was between 56%-75%. The authors also found that JUUL fluids were cytotoxic for all pod flavors. All of the pod fluids were found to be cytotoxic to lung epithelial cells. Most were cytotoxic at 0.2% to 1.8% concentration, with a maximum effect at 10% concentration. Corresponding aerosols were also cytotoxic, and were cytotoxic at levels lower than observed with fluids with maximum effect at 0.2% - 1.8%. Omaiye et al. also tried to determine the relative contribution of nicotine, total flavor chemicals, and individual flavor chemicals to cytotoxicity. They found that nicotine concentration most closely aligned with cytotoxicity. However, the correlation between cytotoxicity and all components was statistically significant. The authors concluded that, "our data clearly identify a [sic] concern related to the high nicotine concentration in JUUL products, i.e., the potential for high levels of nicotine, as well as flavor chemicals such as ethyl maltol, to damage or even kill cells at the concentrations used in JUUL pods."

70. Widely used e-cigarette flavoring impairs lung function [press release]. 2018.

In this press release, the American Thoracic Society summarizes recent research by Clapp et al. entitled, "The E-cigarette Flavoring Cinnamaldehyde Suppresses Mitochondrial Function and Transiently Impairs Cilia Beat Frequency in Human Bronchial Epithelial Cells." The study found that a single exposure to cinnamaldehyde in e-cigarettes impairs lung function. In the press release, the authors state that, "our data suggest that when used in e-cigarettes cinnamaldehyde, like toxic aldehydes in cigarette smoke, significantly disrupts normal cell physiology in ways that may have implications for the development and exacerbation of respiratory disease...our finding that cinnamaldehyde impairs normal airway cilia motility is significant because it demonstrates that a common, food-safe flavoring agent, in the context of e-cigarette use, is capable of dysregulating a critical anti-bacterial defense system in the lungs." The authors note that flavoring agents, while safe for ingestion, may not be safe for inhalation. In addition, since flavoring agents are used in high concentrations in e-cigarettes, individuals may be exposed to higher doses of the agent. Authors state, "The two principles of toxicology- 'The Dose Makes the Poison' and 'The Route of Exposure Affects Toxicity'- clearly apply here."

71. Sherwood C. L., Boitano S. Airway epithelial cell exposure to distinct e-cigarette liquid flavorings reveals toxicity thresholds and activation of CFTR by the chocolate flavoring 2,5-dimethylpyrazine. *Respir Res.* 2016;17(1):57.

Sherwood and Boitano evaluated the impact of e-liquid flavoring chemicals on bronchial epithelial cells, which "provide the first line of defense against inhaled particulates, pathogens, and toxicants." They found that 5 out of 7 flavoring chemicals were cytotoxic and produced effects consistent with cell death. Vanillin and 2,5-dimethylpyrazine, used to provide chocolate flavoring, also compromised cell function at subcytotoxic levels. Very low concentrations (0.02%) of 2,5-dimethylpyrazine "induced distinct cellular impedance changes indicative of a

cellular signaling event.” This type of reaction, “alters the capability of airway epithelial cells to respond to signaling molecules key in the proper functioning of airway cell physiology.”

72. E-cigarettes linked to heart attacks, coronary artery disease and depression [press release]. 2019.

This American College of Cardiology press release summarizes results from a study by Vindhyal et al. presented at the ACC’s 68th Annual Scientific Session (2019). Vindhyal et al. reported that there are over 460 brands and 7,700 flavors of e-cigarettes. Vindhyal et al. analyzed data from 96,467 respondents to the National Health Interview Survey from 2014, 2016, and 2017. They found that adults who use vapor products are significantly more likely to have a heart attack, coronary artery disease, and depression compared to those that do not use vape products. For example, after controlling for age, sex, body mass index, high cholesterol, high blood pressure, and smoking combustible cigarettes, adults that used e-cigarettes were 34% more likely to have a heart attack and 25% more likely to have coronary artery disease compared to adults that do not use e-cigarettes. Users were at increased risk of heart attack and coronary artery disease regardless of whether they vaped daily or occasionally. The authors noted that further longitudinal data is needed to establish causation. However, the authors stated that the results “show a clear association between any kind of smoking and negative health outcomes.”

73. Bayly J.E., Bernat D., Porter L., et al. Secondhand Exposure to Aerosols from Electronic Nicotine Delivery Systems and Asthma Exacerbations Among Youth With Asthma. CHEST. 2018; Ahead of print.

Bayly et al. analyzed data from the 2016 Florida Youth Tobacco Survey to determine whether there was a relationship between secondhand exposure to aerosol from electronic nicotine delivery systems (ENDS) and asthma exacerbation among youth with asthma. They examined survey responses for youth aged 11 to 17 years old from middle and high schools in Florida. Overall, approximately one-third of youth reported secondhand exposure to ENDS aerosols. The authors found that secondhand exposure to aerosol from ENDS was significantly associated with higher odds of asthma attacks among youth with asthma ($p < 0.01$; OR 1.27, 95% CI 1.11-1.47). The authors concluded that, "secondhand exposure to ENDS aerosols may be related to asthma symptoms in youth...future research is necessary to evaluate the longitudinal relationship between secondhand ENDS aerosol exposure and asthma control."

74. Bhatnagar A., Whitsel L. P., Blaha M. J., et al. New and Emerging Tobacco Products and the Nicotine Endgame: The Role of Robust Regulation and Comprehensive Tobacco Control and Prevention: A Presidential Advisory From the American Heart Association. Circulation. 2019;139(19):e937-e958.

In its Presidential Advisory on New and Emerging Tobacco Products, the American Heart Association (AHA) highlighted the dramatic increase in use of electronic cigarettes (e-cigarettes), particularly among adolescents and young adults, as a significant health concern. AHA stated, “[a]lthough these products may benefit by helping some smokers to quit or to move to a less harmful product, the long-term health effects of these products and the net public health effect associated with their use remain unclear and widely debated.” Evidence indicates that use of e-cigarettes by youth “seems to be nearly exclusively for recreational purposes because youth use does not seem to be associated with quit attempts or quit contemplation.” The National Academies of Sciences, Engineering, and Medicine summary of the latest research on e-cigarettes

indicates that these products “contain fewer numbers and lower levels of toxicants than combustible tobacco cigarettes and that exposure to nicotine and toxicants from aerosolization of e-cigarette constituents depended on the characteristics of the device and its use.” Upon review of the evidence, the committee found that “e-cigarettes likely pose less risk than continuing to smoke cigarettes”, but that e-cigarettes are “not without adverse biological effects in humans.” Population dynamic modeling conducted before the rise in JUUL use indicated that, “assuming that the use of e-cigarettes increases the net cessation rate of combustible cigarettes among adults, the use of these products could generate a net public health benefit, despite the increased use of combustible tobacco products by young adults.” However, the modeling also showed that “in some scenarios in which e-cigarette toxicity was much higher or the gateway effects from e-cigarette use to combustible cigarette use were much stronger, the public health benefit was substantially less or e-cigarette use was even associated with net harm. Moreover, if e-cigarettes do not promote cessation of combustible tobacco products in adults, the policy model projected that there would be net public harm in both the short and long terms.” The committee therefore “prioritized research to determine whether e-cigarettes promote smoking cessation.” AHA noted that data documenting the increasing use of e-cigarettes among adolescents and young adults may underestimate the true prevalence because evidence indicates that “some youth self-report that they are not using e-cigarettes when they are using electronic hookah, JUUL, and other similar products.” A growing body of evidence shows that young people who use e-cigarettes, particularly products with higher nicotine content, “are more likely than those not using these products to try and to continue cigarette smoking.” Evidence also indicates that e-cigarettes may contribute to former smokers reinitiating tobacco use and sustaining nicotine use. A population-based, prospective cohort study found “no evidence that e-cigarette use helps adult smokers quit at rates higher than when these products are not used.” Moreover, while dual users may smoke fewer cigarettes, they tend to compensate with more e-cigarette use, which increases their overall exposure to nicotine. “Therefore, even though e-cigarettes might help maintain smoking reduction and lower withdrawal symptoms, the long-term health impact of dual use remains largely unknown.” AHA noted that, to date, “there is no experimental evidence to support the view that flavors help adults switch from combustible tobacco products or to quit tobacco altogether.” However, evidence suggests restricting flavoring in all tobacco can reduce the appeal of these products to adolescents and young adults.

75. QxQ Analysis: Cigarette Use by Race/Ethnicity, Sexual Orientation, and Gender Identity. Looking Glass Analytics; 2018. <http://www.askhys.net/Analyzer>. Accessed September 2019.

Washington State Healthy Youth Survey data from 2018 indicate that among 8th grade respondents American Indian/Alaskan Native (AI/AN) students (5.8% [95% CI 2.9-8.5%]) and black students (5.0% [95% CI 2.4-7.6%]) reported higher smoking rates than their Asian or Asian American, Native Hawaiian or other Pacific Islander (Asian/NHOPI) (1.8% [95% CI 0.9-2.7%]), white (2.2% [95% CI 1.5-2.9%]), and Hispanic peers (3.4% [95% CI 2.4-4.4%]). Among 10th grade respondents, black students (6.0% [95% CI 4.0-8.0%]), Hispanic/Latino students (6.0% [95% CI 4.7-7.3%]), and students of more than one or other race/ethnicity (6.4% [95% CI 4.9-7.9%]) reported higher smoking rates than their peers. Generally, the percent of students who had reported smoking at all in the past 30 days was highest among 12 grade respondents. AI/AN (10.5% [95% CI 4.2-16.8%]) respondents and those who selected more than one or other race/ethnicity (10.2% [95% CI 7.4-13%]) reported higher cigarette smoking rates than their peers

with 9.5% (95% CI 7.7-11.3%) of white youth smoking. These data suggest that in Washington State, AI/AN, black, and multi or other racial/ethnic youth have disparately high rates of current cigarette use. It is important to note that the current race/ethnicity categories aggregate diverse subpopulations into one category—so disparities within these categories may be masked. For example, API subpopulations likely have very different smoking rates but they are aggregated into one category so these differences may be missed. Students from the subsample of schools who participate in the extended form version of the Healthy Youth Survey also answered questions about their sexual orientation. Eighth grade respondents who identified as lesbian, gay, or bisexual were more likely to report smoking cigarettes at all in the last 30 days (5.3% [95% CI 3.2-7.4%]) than their peers who identified as straight (1.9% [95% CI 1.3-2.5%]). This disparity also existed among 10th graders (10.8% [95% CI 8.4-13.2%] vs. 3.7% [95% CI 3.1-4.3%]) and 12 graders (16.0% [95% CI 11.9-20.1%] vs. 5.9% [95% CI 4.8-7.0%]). A similar disparity exists across grade levels for students who report either questioning their sexual orientation or who feel something else (besides gay, lesbian, bisexual, or straight) fits better. Finally, the Healthy Youth Survey also asks students about their gender identity. Eighth grade data were suppressed due to fewer than 5 responses in at least one category. Among 10th grade respondents who identified as transgender were more likely to report smoking cigarettes at all in the last 30 days (22.4% [95% CI 12.6-32.2%]) than their peers who identified as cisgender female (4.3% [95% CI 3.2-5.4%]) or cisgender male (4.4% [95% CI 3.6-5.2%]). This disparity also existed among 12th graders (transgender students: 37.3% [95% CI 20.9-53.7%] vs. cisgender female 5.5% [95% CI 3.9-7.1%] or cisgender male (7.9% [95% CI 6.0-9.8%])). Similar disparities exists across grade levels for students who report questioning/not sure of my gender identity, something else fits better, and who selected more than one response.

76. Chaiton M. O., Nicolau I., Schwartz R., et al. Ban on menthol-flavoured tobacco products predicts cigarette cessation at 1 year: a population cohort study. *Tob Control*. 2019.

Chaiton et al. conducted a population cohort study to analyze the long-term impact of a menthol ban in Ontario, Canada, on smoking behavior. Authors cited evidence from the FDA's scientific evaluation that "menthol has a physiological impact on smoking that increases initiation and progression to regular cigarette smoking, increases nicotine dependence and decreases smoking cessation success." Menthol sales account for 5% of the cigarette sale market in Canada, while in the U.S. menthol cigarettes account for 35% of the market. The FDA also noted younger populations, women, and black Americans were more likely to smoke menthol cigarettes--which "perfectly matched the targeted marketing strategies employed by the tobacco industry." Similar to the U.S., a considerable number of Canadian youth report smoking menthol cigarettes. "According to the 2010–2011 Canadian Youth Smoking Survey, as many as 32% of current cigarette smokers used menthol cigarettes, and in the 2012–2013 iteration, almost 15% of students from grades 10–12 reported using [flavored] tobacco (including menthol products)." Baseline survey results were collected before the menthol ban (September-December 2016) and follow-up surveys were conducted 1 year after the implementation of the ban (January-August 2018). Participants included residents of Ontario, Canada, ages 16 years and older who reported current smoking (past 30 days) at baseline and completed a follow-up survey. Of participants, 58% were female; 84% were over age 30 years; 83% were white; 71% had more than a high school degree; 39% smoked from 11-20 cigarettes a day; and 10% were non-daily smokers. Researchers assessed past year use of menthol cigarettes prior to the ban and current use of

menthol and non-menthol cigarettes following the ban. Researchers evaluated "quitting" as the primary outcome and "quit attempts" as a secondary outcome. Quit attempts were defined as "self-reporting making a serious quit attempt since the beginning of the menthol cigarette ban in January 2017." Additionally, all those who reported not smoking at follow-up were considered to have made a quit attempt. The use of e-cigarettes or cigars since the ban was also assessed. Of participants with complete data (n=913), 21% (187) reported smoking menthol cigarettes daily, 46% (420) reported smoking menthol cigarettes occasionally, and 34% (306) were non-menthol cigarette smokers. "Daily and occasional menthol smokers were more likely to be female, non-white and have more than a high school education than non-menthol smokers." The highest percentage of young adult (i.e., 16 to 29 years of age) smokers was seen among those who smoked menthol cigarettes occasionally. "At follow-up, 0.3% of the non-menthol smokers at baseline, 5% of the occasional menthol users and 22% of the daily menthol users reported purchasing menthol cigarettes after the ban (p<0.001). The primary source for purchasing menthol cigarettes was on First Nation Reserves, but this purchasing pattern did not increase over time among prior daily menthol smokers (short-term follow-up: 21%; long-term follow-up: 21%)." This is consistent with previous research findings that "25% of menthol smokers claim that they would find some way to purchase menthol cigarettes despite a ban." Among the overall study sample, 19% of baseline smokers reported successfully quitting smoking, and 56% reported making a quit attempt after the ban. Quit rates reported by non-menthol smokers were "consistent with a previous population-representative longitudinal studies of quit rates in Ontario (8.9% sustained self-reported quit rate)." Meanwhile, "[d]aily menthol smokers had significantly higher rate of reporting having quit smoking after the ban (adjusted rate ratio [AAR] 1.62; 95% CI 1.08 to 2.42) compared with non-menthol smokers, controlling for smoking and demographic characteristics." Daily menthol smokers were also more likely to have tried to quit than non-menthol smokers (AAR 1.25; 95% CI 1.03-1.50), after adjustment. Both findings were statistically significant (p<0.05). Sensitivity analyses, which included those who did not complete the follow-up survey (N=1,738) as having continued smoking did not change the significance of results "nor did it greatly alter the magnitude of estimates." Study results found that "menthol smokers who intended to substitute with other means had substantial levels of quitting behavior." Specifically, "20% of occasional menthol smokers and 24% of daily menthol smokers reported quitting in the long terms, which exceeded what was predicted by smokers at baseline." Moreover, findings suggested an increased rate of quitting 1 year following Ontario's ban on the sale of menthol tobacco products. However, the impact was observed in older but not younger adults. Authors postulated that "the difference may be due to younger adults not having a brand preference and switching to other tobacco or nicotine products." Authors noted a combustible tobacco menthol ban would be more impactful for at-risk subpopulations of youth and young adults if there was less availability of other flavored tobacco or nicotine products. Finally, there was no public education campaigns informing the public of the menthol ban, and the ban was implemented without noticeable controversy. Authors conclude that "[C]onsidering that menthol smokers may be more nicotine dependent and have reduced cessation success, our findings that daily menthol smokers were significantly more likely to reporting smoking cessation relative to non-menthol smokers after the ban suggest that the menthol ban could have tremendous public health impact at the population level in Canada and in other jurisdictions as well from an overall reduced level of cigarette smoking."

77. Christenson T., Weisser, J. Health of Washington State Report: Tobacco Use. Washington State Department of Health; 2015.

Combined 2012-2014 Behavioral Risk Factor Surveillance System (BRFSS) data indicate that AI/AN adults in Washington have significantly higher rates of current cigarette use than their white, black, Hispanic/Latino, and Asian counterparts. Cigarette use also decreased significantly as educational attainment or income increased. This report also indicates that smoking rates among gay, lesbian, and bisexual respondents were significantly higher than for their straight counterparts. These BRFSS data and 2014 Healthy youth survey data also show that smoking prevalence is highest in late adolescence and early adulthood, peaking among 25-34 years old for men and women. Pregnancy Risk Assessment Monitoring System (PRAMS) data from 2010-2012 indicate that the smoking rates among pregnant women before and during pregnancy are highest among mothers younger than 20 (36% [95% CI 28-45%]). Thirty-two percent of mothers age 20-24 also reported smoking before and during pregnancy (95% CI 27-37%) compared to 9% (95% CI 6-12%) of mothers 35 years or older. These data also indicate that smoking before pregnancy is highest among AI/AN (50% [95% CI 45-55%]) and low-income mothers. Because women often are not aware that they are pregnant until several weeks into their pregnancy, the smoking rates in the months leading up to pregnancy can have an important impact on fetal development and growth.

78. San Mateo County, CA. Data USA 2018; Available at: <https://datausa.io/profile/geo/san-mateo-county-ca/>. Accessed September, 2019.

Data USA is a collaboration by Deloitte, Datawheel, and Professor Cesar Hidalgo at the MIT Media Lab and Director of Collective Learning. It presents public US Government data from multiple data sources. Analysts accessed 2017 median household income data for San Mateo County, San Francisco County, and California.

79. What we know about electronic cigarettes. 2019; Available at. Accessed 9/9/2019.

The smokefree.gov website outlines information about e-cigarettes and health risks. The site also explains that, "e-cigarettes are not approved by the FDA as a quit smoking aid. So far, the research shows there is limited evidence that e-cigarettes are effective for helping smokers quit." The site states that e-cigarettes still contain nicotine and other harmful substances.

80. Wang R., Bhadriraju S., S.A. Glantz. E-cigarette use and adult cigarette smoking cessation: A meta-analysis. *American Journal of Public Health*. 2021;Epub.

As of November 2020, e-cigarettes had not been approved as a smoking cessation medication by the U.S. Food and Drug Association (FDA). Wang et. al. conducted a systematic review of 64 articles and meta-analysis to determine the association between e-cigarette use and smoking cessation. They found that, "as consumer products, in observational studies, e-cigarettes were not associated with increased smoking cessation in the adult population. In [randomized control trials], provision of free e-cigarettes as a therapeutic intervention was associated with increased smoking cessation."

81. Schier J.G. et al. Severe Pulmonary Disease Associated with Electronic-Cigarette-Product Use-- Interim Guidance. *Morbidity and Mortality Weekly Report*. 2019;68:2-4.

On September 6, 2019, Centers for Disease Control and Prevention issued interim guidance related to the outbreak of severe pulmonary disease associated with e-cigarette use. This

Morbidity and Mortality Weekly Report states that, “based on available information, the disease is likely caused by an unknown chemical exposure; no single product or substance is conclusively linked to the disease...until a definitive cause is known, persons should consider not using e-cigarettes.” In addition, “e-cigarette products should never be used by youths, young adults, pregnant women, or by adults who do not currently use tobacco products. Adult smokers who are attempting to quit should use evidence-based smoking cessation treatments, including counseling and FDA-approved medications.” They note that most patients have presented with hypoxemia, which has progressed to acute or subacute respiratory failure, requiring some patients to receive oxygen, intubation, or mechanical ventilation. Case studies with 53 patients in Illinois and Wisconsin, 6 patients in Utah, and 5 patients in North Carolina, have found that all patients, “have had abnormal radiographic findings, including infiltrates on chest radiograph and ground glass opacities on chest computed tomography scan.” Ground glass opacities refers to findings showing a filling of air spaces or a thickening or collapse of lung alveoli. The authors explained that, “no consistent e-cigarette product, substance, or additive has been identified in all cases, nor has any one product or substance been conclusively linked to pulmonary disease in patients.” All patients have used vapor products containing THC, nicotine, or both.